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CONTENTS

	Page
Nuclear Energy Development as a Problem of Man-power	343
New Ideas about Muscles. By Prof. J. D. Bernal, F.R.S.	345
A Hundred Years of Chemical Industry. By J. L. S. Steel	347
The Statistical Description of Vegetation. By Prof. W. H. Pearsall, F.R.S.	347
Science for Students of the Humanities. By J. A. Ratcliffe, O.B.E., F.R.S.	348
Theoretical Optics. By G. R. Noakes	348
History of Iron in Britain. By Prof. F. C. Thompson	349
Separation of Light and Dark Phases in the Photosynthesis of Isolated Chloroplasts. By Dr. Achim V. Trebst, Harry Y. Tsujimoto and Prof. Daniel I. Arnon	351
The John Curtin School of Medical Research, Australian National University	355
High Energy Nuclear Physics. By Dr. G. H. Stafford	356
News and Views	358
Progress in Cancer Research. By Prof. H. N. Green	364
British Rayon Research Association. By L. A. Wiseman	365
Design and Management of a Nuclear Science Laboratory. By Prof. A. J. Woodall, O.B.E., C. G. Wilson, Dr. A. L. Jones and D. K. Thomas	367
The Electrical Research Association. By Prof. J. Greig	369
Genetics of Beta-Globulin Polymorphism in British Cattle. By G. C. Ashton	370
Group-Translocation : a Consequence of Enzyme-catalysed Group-Transfer. By Dr. Peter Mitchell and Dr. Jennifer Moyle	372
Oxidative Metabolism of Polycyclic Hydrocarbons by Soil Pseudomonads. By H. N. Fernley and Prof. W. C. Evans	373
Etching of Radiation Damage in Lithium Fluoride. By Dr. D. A. Young	375
Effect of Hyaluronidase on Capillary Permeability, Lymph Flow and Passage of Dye-labelled Protein from Plasma to Lymph. By Dr. G. Szabó and S. Magyar	377
Gravimorphism in Trees. By Dr. P. F. Wareing and T. Nasr ; K. A. Longman and Dr. P. F. Wareing	379

Letters to the Editors :

Polar Wandering, a Random Walk Problem.—R. Green	382
Secular Variation in the Direction of Geomagnetism as the Standard Scale for Geomagnetochronology in Japan.—Naotune Watanabe	383
Measurement of the Thickness of the Earth's Crust in the Albertan Plains of Western Canada.—Dr. T. C. Richards	384
Influence of the Semi-Permanent Low-Level Ocean Duct on Centimetre Wave Scatter Propagation beyond the Horizon.—F. A. Kitchen, W. R. R. Joy and E. G. Richards	385
Determination of Traces of Oxygen in Sodium Metal by Infra-red Spectrophotometry.—H. J. de Bruin and L. E. Smythe	387
A New Configuration of Deoxyribonucleic Acid.—D. A. Marvin, M. Spencer, Dr. M. H. F. Wilkins and L. D. Hamilton	387
A Three-stranded Polyribonucleotide Structure.—Dr. Geoffrey Zubay	388
Vibrational Frequency associated with the Boron–Nitrogen Dative Bond in Amine Boranes.—R. C. Taylor and C. L. Cluff	390
Molecular Structure of *cyclo*-Octatetraene.—I. J. Lawrenson and Dr. F. A. Rushworth	391
Use of Molecular Sieves in Gas Chromatography for the Determination of the Normal Paraffins in Petroleum Fractions.—B. T. Whitham	391
Swift Combustion of Organic Compounds for Analysis.—Dr. Irmgard K. H. Otter	393
Some Complex Cyanides of Rhenium.—Dr. R. Colton, Prof. R. D. Peacock and Prof. G. Wilkinson	393
Moving Acid Boundary (pH Gradient) Paper Ionophoresis of Bile Salts.—Thomas Briggs, Dr. Michael W. Whitehouse and Dr. Ezra Staple	394
Experimental Chemotherapy of Tumours with Hydrogen Peroxide.—Dr. M. Chorazy, A. Gettlich, L. Góral, B. Kołoczek, E. Molawka, B. Penar and Z. Szweda	395
Anticholesterol Activity of α-Lipoic Acid.—David Kritchevsky and A. W. Moyer ; Dr. L. Angelucci and E. Mascitelli-Coriandoli	396
Existence and Significance of a Physiological Anticoagulating System.—Prof. B. A. Kudrjashov and P. D. Ulytina	397
Carbohydrate Metabolism of Cock Spermatozoa.—Prof. F. W. Lorenz	397
Distribution of Newly Synthesized Deoxyribonucleic Acid in Mitotic Division.—Prof. W. Plaut ; Prof. Henri Firket	399
Comparison of the Salivary Secretion of Both Parotid Glands in a Sheep.—M. Somers	400
Desertomycin, a New Crystalline Antiblotic with Antibacterial and Cytostatic Action.—Dr. J. Uri, R. Bognár, I. Békési and B. Varga	401
Adrenalectomy and Tissue Amines.—R. Hicks and Dr. G. B. West	401
Lethal and Sterilizing Effects of Single and Fractionated Doses of Gamma Radiation on *Calandra granaria* L.—D. J. Jefferies and P. B. Cornwell	402
Dosage–Mortality Curves for Houseflies Susceptible and Resistant to DDT.—K. Wilson-Jones and G. Davidson ; Dr. P. S. Hewlett	403
Ecology of the Louse *Lepidophthirus macrorhini* Enderlein 1904 on the Elephant Seal *Mirounga leonina* (L.).—M. D. Murray	404
Natural Relationships of the Nitrogen-fixing Bacteria.—Dr. K. A. Bisset	405
Growth-promoting Activity of Potato Tuber Extracts in the Coleoptile Straight-Growth Test : Quantitative Aspects of Indoleacetic Acid Detection.—A. Booth and Dr. P. F. Wareing	406
δ-Acetylornithine : a Constituent of some Common Grasses.—Dr. L. Fowden	406
Photoperiodic Response of the House Sparrow, *Passer domesticus*.—Dr. L. T. Threadgold	407
The Hood of the Hooded Seal, *Cystophora cristata* Erxl.—Björn Berland	408
Genetic Hazard of Ionizing Radiations.—Dr. T. C. Carter, Mary F. Lyon and Rita J. S. Phillips	409
Possible Autosomal Linkage in Man.—Dr. A. M. O. Veale	409
Migration of Spleen Cells from Subcutaneous Implantation Sites.—Dr. V. Hašková and Dr. N. A. Mitchison	410

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NUCLEAR ENERGY DEVELOPMENT AS A PROBLEM OF MAN-POWER

THE White Paper on "Capital Investment in the Coal, Gas and Electricity Industries"* which was presented to Parliament in April gave the latest information about investment in 1957 together with the approved expenditure for 1958–59. It thus provides something of the background against which to consider the changes in the nuclear power position in Britain since announced, and to which the development of Euratom and particularly the provision of help from the United States have given added interest. Of the approved capital expenditure of £440 million in 1957 compared with an actual £390 million in 1956, £233 million and £206 million, respectively, were on account of the Central Electricity Authority, with a further £20 million and £17 million for the South of Scotland Electricity Board and £21 million and £20 million for the North of Scotland Hydro-Electricity Board. For 1958, out of £436 million approved, the corresponding figures are £239 million, £26·5 million and £17 million, respectively. Of this latter expenditure, no more than some £45·5 million is accounted for by nuclear power stations (including £8·5 million at Hunterston), although in England and Wales estimated expenditure on nuclear stations in 1957–58 was £21 million compared with £37 million approved for 1958–59 and represented continuing work at Bradwell and Berkeley and the commencement of work at Hinkley Point.

As already announced, the White Paper points out that work on new power stations is to be spread over the next 26 instead of 24 months, and the completion of the nuclear power programme is to be postponed for a year, while a higher proportion of the total new generating capacity will be in the form of coal-fired stations at lower capital cost. The decision of the Ministry of Defence that some of the nuclear power stations should be modified to produce plutonium of weapons grade represents, however, a much more considerable modification of the programme. The Paymaster-General, Mr. R. Maudling, explained in the House of Commons on June 24 that the modifications proposed at Hinkley Point and the next two stations in the programme of the Central Electricity Generating Board would not impair the efficiency of the stations and that the initial capital cost and any additional operating costs that may be incurred would be borne by the Government. On June 30 Sir Ian Horobin said in Parliament that the capital cost of the modifications was unlikely to exceed 1 per cent of the cost of the stations concerned and that building progress would not be affected.

While, therefore, the price of electricity may not be affected and the country may in fact be provided at comparatively small cost with a valuable insurance against possible future defence needs, this statement scarcely represents the full implications of this change in design. To obtain plutonium suitable for military purposes, the fuel rods must be renewed at intervals of months rather than of years, and the gross costs will undoubtedly be altered for the worse if fuel costing £10 million or more may all be removed by the end of the year instead of remaining in the reactor for five years. Apart from this, there will be the loss of experience in the probable life of fuel elements; and the processing plants of the Atomic Energy Authority, particularly the diffusion plant at Capenhurst and the chemical treatment plant at Windscale, are likely to be so overloaded that further capital investment by the Authority seems inevitable.

The cost of installing discharging mechanisms and cooling ponds of greater capacity is unlikely to be high, but diffusion plant and chemical treatment plant may be another matter. Serious interference with the nuclear power programme will arise because the plutonium is diverted to military purposes instead of being used to convert infertile material into nuclear fuels. To that extent more uranium will have to be mined and processed, and purchased; and some of the capital on which later reductions in the cost of electricity might be based will in effect be used for that purpose. Moreover, apart from the loss of experience already noted, it is possible that in the immediate future a shortage of plutonium for experimental purposes could retard technical innovations.

Nor is this the whole price to be paid. The rigorous distinction which Britain has hitherto made between its nuclear power programme now disappears, and the dual character of nuclear power stations is, on the contrary, emphasized. This has diplomatic as well as economic drawbacks, and no convincing reasons have yet been given to show that, on balance, the necessary supplies of plutonium would not have been obtained more advantageously by building a new reactor, or by more urgent efforts to utilize the over-abundant stocks built up in the United States—an attempt that the agreement on the exchange of nuclear weapon information signed in Washington on July 3 should facilitate, for it provides specifically for the supply of enriched uranium to the Atomic Energy Authority in Britain.

The change in policy will do nothing to remove the difficulties which it is believed in some quarters that the nuclear power industry is facing. Mr. A. L. G. Lindley, managing director of the General Electric Co., Ltd., expressed the view earlier in the year that no more than six additional orders for nuclear power stations would be placed by the Central Electricity Generating Board in the three years from 1959 compared with the dozen or more additional stations mentioned last year; nor did he expect much profit would accrue to British firms from the export of nuclear power stations, even though many nuclear power stations might be built to British design abroad. On the technical side, too,

* Capital Investment in the Coal, Gas and Electricity Industries. Pp. 8. (Cmnd. 415.) (London: H.M. Stationery Office, 1958.) 6d. net.

there is some evidence that builders of nuclear power stations have entered a period of diminishing returns from expenditure on research and development. Sir Christopher Hinton has confirmed this in warning the industry to avoid the difficulties of structure which beset the aircraft industry. From the end of this year, he said, the Board would be placing orders for two main conventional power stations and two nuclear power stations compared with the ten or more power stations ordered every year since the War, the reason being the high capacity of plant which would now be built in a single unit. He thought, too, that within his life-time the future of nuclear power in Britain would be based on developments of the Calder Hall reactor, and he did not expect fusion power of the kind which ZETA may tap to become important industrially for thirty-five or forty years.

The overdue agreement on the exchange of nuclear information between Great Britain and the United States may prove the latter forecast too pessimistic, for the freer the interchange of information in projects of this type the less likely is progress to be retarded by lack of contact or faulty judgment. Frank and free and informal discussion with other scientists and technologists is the best stimulant of the critical judgment and creative thinking which lie at the root of technological and scientific advance. It should be noted that in replying on an adjournment debate in the House of Commons on March 20, the Parliamentary Secretary to the Ministry of Power, Sir Ian Horobin, was confident that restrictions had not stunted our scientific effort in this field and that we had found happy and practical relations between the Atomic Energy Authority and industry. Whether or not Sir John Cockcroft is right in believing that there is no military use for thermonuclear fusion, scientists should make sure that the utmost use is made of the agreement resulting from the doctrine of interdependence which the Prime Minister and President Eisenhower proclaimed jointly last autumn.

The change in policy may bear equally on Britain's relations with Euratom. Even before the announcement on June 28 that Euratom was to receive massive financial and technical help from the United States, the Government had been for some time closely questioned in Parliament regarding British relations with Euratom. Like other member countries of the Organization for European Economic Co-operation, Great Britain is a member of the European Nuclear Energy Agency, the statute for which was published in a White Paper last February; this provides for close collaboration with Euratom, the members of which are also members of the Agency. On May 22 Mr. R. A. Butler told the House of Commons that the Prime Minister had suggested to the President of the Euratom Commission that, until Euratom had selected its permanent headquarters, the head of the United Kingdom delegation to the High Authority of the Coal and Steel Community should also be accredited to the Euratom Commission. He had also proposed that we should negotiate an agreement for technical collaboration, providing the framework for co-operation between the British Government and Euratom, to facilitate co-operation both between individuals and between individual industrial concerns, and complementary to the general co-operation on nuclear affairs in Western Europe as a whole through the European Nuclear Energy Agency.

Mr. Butler said that these proposals had been welcomed by Euratom, but on June 17 the Prime Minister could only add that preliminary discussion on this technical collaboration agreement were starting that week. On July 1 the Prime Minister said in Parliament that nuclear power plants were unlikely to be bought by the European Atomic Energy Community itself, but rather by individual undertakings in member countries. A number of such inquiries had been received by United Kingdom manufacturers and a letter of intent had been signed between an Italian undertaking and a United Kingdom group. The Government hoped to conclude agreements with the Community and, as appropriate, with member Governments, to provide the framework within which such exports could take place, and such an agreement was already in force with the Italian Government.

Mr. Macmillan pointed out that the supply of United Kingdom reactors, which were fully developed and available on ordinary commercial terms, was governed by very different circumstances from those which led to the United States–Euratom agreement. The latter agreement provides the framework for the joint construction of prototype reactors of American design which are still in the development stage. Under it, the United States will assist Euratom in a ten-year programme of reactor research and development for which 100 million dollars will be provided in the first five years to build five or six nuclear power stations for commissioning in 1963. These stations, which are likely to be of the pressurized-water reactor type, will have a total generating capacity of about 5 million kilowatts, and for the construction, estimated at 350 million dollars, about 135 million dollars will be provided as long-term United States credits to Euratom. The United States will also provide enriched uranium for these plants at prices regarded by the West as 'give-away' prices, and the United States Atomic Energy Commission will guarantee for twenty years the endurance of the fuel elements under the agreement.

The contribution to the fuel economy of the six Euratom countries will not be important for its own sake, but the construction and operation of the reactors will allow the establishment of a cadre of nuclear technologists essential for larger developments. The agreement may also assist in the development of nuclear technology in the United States by expanding the opportunities for prototype trials; but there is nothing in this to be interpreted as a blow to British prestige or to offset the very definite advantages which Britain possesses. It would be wrong, as Sir Claude Gibb has emphasized, to over-stress the opportunities which export trade in nuclear power offers to Britain. In his view, the main assets which Britain has to offer to highly

industrialized countries are her experience in design detail, in construction and in operation, and these hold potentialities for the reduction of initial capital costs which the Euratom countries are unlikely to overlook.

Friendly contacts have already been established in London with Euratom representatives, and the very great possibilities of the reactor chosen by Britain will certainly be recognized. It can be built, for example, by quite modest extension of conventional engineering techniques, and offers good prospects of decreased capital costs. The use of natural uranium is a further advantage, for in view of the distribution of uranium, most countries employing this type of reactor could look forward to becoming self-supporting in fuel supplies.

Power stations of this design thus can, and probably will, be sold in Europe while the American construction programme gets under way; and there is no reason for being pessimistic about the future of developments in Europe because of the Euratom agreement with the United States, provided due regard is had, first to our relations with Euratom, and secondly, but no less important, to the magnitude of the British nuclear power programme in relation to the other demands on our limited resources. Mr. Macmillan's statement indicates the Government now realizes the importance of establishing our relations with Euratom on a proper footing, and that something more than a research link is needed; but whether the Government appreciates the significance of the second point is still rather doubtful.

The reply to a question in the House of Commons on July 1 disclosed that the survey of expenditure on research and development made in 1955 is still being examined, and no plans have yet been made for a further survey. Yet, to take one point alone, the demand on Britain's scientific and technical manpower, as well as on material resources, should have been one factor to be considered in determining how best to meet our need for plutonium, if not the magnitude of those needs. Sir Claude Gibb recently estimated that the British nuclear industry is already employing 10,000 engineers and scientists on research and development, and said that the effort to prepare tenders for one of the first 300-MW. nuclear power stations in Britain approaches 1,000 man-years—the figure which Sir Edwin Plowden has given for initial research and development after the completion of basic research study of feasibility. Considering his further estimates that, for one year's study of feasibility and an experimental reactor, fifteen to a hundred scientists or engineers may be required, 100–150 engineers for a year's work on reactor design, a staff of 200 for a two-year study of the reactor and 100 for the three years to build a prototype reactor and control experiments with the reactor, and that, including the necessary support facilities, each professional scientist or engineer employed costs the Atomic Energy Authority about £10,000, the magnitude of the effort required from the limited scientific and engineering man-power of Britain becomes apparent.

This effort by the Atomic Energy Authority—and its further part in training technologists—has to be added to the 10,000 employed already in nuclear work by industry, and to the effort in nuclear research which the universities are also making, and to which the Department of Industrial and Scientific Research makes significant grants. Doubts may well be felt as to how far Britain is able to support an export programme in nuclear power; but there can be none as to urgency of the task of expanding our resources in scientific, technological and technical man-power. The over-riding message of the White Paper on capital investment in the coal, gas and electrical industries, however, is the vital and urgent need for as accurate assessment as possible not simply of the demands which nuclear power is making on capital and other material resources but of its demands on the scientific and technical manpower of Britain and its relation to the magnitude and distribution of our effort in research and development generally. Only when the magnitude of nuclear power development is seen in proportion to the national effort and resources generally can it be judged whether the balance is sound and how far further development is prudent.

NEW IDEAS ABOUT MUSCLES

Bioenergetics

By Albert Szent-Györgyi. Pp. x+143. (New York: Academic Press, Inc.; London: Academic Books, Ltd., 1957.) 4.50 dollars.

"THERE is but one safe way to avoid mistakes—to do nothing—or at least to avoid doing something new. This, however, may be the greatest mistake of all." With these characteristic words Szent-Györgyi prefaces his book on bioenergetics. If his scientific readers expect to get from his book a precise report on ascertained facts they will be disappointed. Szent-Györgyi's work has throughout been marked by its bold advances, by its intuitions which, seeming rash at the time, are afterwards found to be verified.

In the field of muscle physiology, which still remains his chief centre of interest, if anyone so exuberant can be limited to one centre, his speculations and experiments of twenty years ago on actin and myosin were first of all regarded as fantasies but have now become the cornerstone of muscle biochemistry. Anyone who disregards Szent-Györgyi's intuitions takes a very big risk—they may turn out to be true. In this book he is speculating about one of the aspects of living structure which has usually fallen by the way, but which is essentially the main one of all. The problem is, in his own words, "How does energy drive life?"; "How does it move the living machine?" It is this problem, first in relation to muscle contraction and later on in the book related to many aspects of living performances, that Szent-Györgyi has his new suggestions to make. It is essentially an attempt to weld together ideas on physiological actions, on quantum relations, particularly with regard to excited states, especially the triplet state, and to examine the action of the chief magician of biological systems, adenosine triphosphate and its so-called energy-rich phosphate bond. It is true that the richness of the bond has been somewhat deflated in

recent years, but it still remains a most remarkable fact that nearly all the energy changes that have been carefully studied in living systems operate through the making or breaking of such bonds and it is usually in connexion with adenosine triphosphate or very similar substances. It was Szent-Györgyi himself, refining the work of Needham and Engelhardt, who showed that the contraction of muscle is, as he says, "essentially the interaction of acteomyosin with ATP and ion". Most other biochemists would say it is associated with, or connected with this interaction, but Szent-Györgyi scorns any such qualifications.

He produces in his first chapter a picture of muscle contraction based on the rearrangement, inside an elongated myosin molecule, of the far smaller globular proteo-myosin molecules of molecular weight 4,500. Such reorganization has, however, still to be demonstrated. It seems more and more unlikely in view of the detailed picture presented by the electron microscope in the hands of Huxley and others. Indeed, any mechanism of muscle contraction involving the chain-length of a particular filament is probably inadequate. However, this does not effect Szent-Györgyi's subsequent argument, which is mostly concerned with how the energy needed for contraction gets into the muscle filament. Essentially, Szent-Györgyi's hypothesis can be written in his terms in the formula:

$$\xleftarrow{\text{muscle activity, luminescence}}$$
$$E_n \ldots \rightleftarrows E_3 \rightleftarrows E_2 \rightleftarrows E_1 \rightleftarrows E^* \rightleftarrows h\nu \text{ or } w$$
$$\xrightarrow{\text{photosynthesis}}$$

where E_n represents the energy reserve of the system and $h\nu$ or w, as the case may be, the light or mechanical work absorbed or given out. The characteristic feature on which he lays stress is the term marked E^* interposed between the last energy state and the final quantum product. This is the excited molecular stage. Szent-Györgyi here postulates the need for a special molecular configuration to allow this energy to travel from one part of the molecule to the other. These considerations lead him into a study of the photo-emission and photo-absorption of molecular systems, with the phenomena of fluorescence, phosphorescence and quenching. The intermediate states of the electronic excitation system can pass, exceptionally, through triplet forms, and these triplet forms of excitation he treats rather in the same way as the free radicals. As in the case of free radicals he imagines them to be immobilized in suitable states, particularly the glassy state. He equates the energy of the energy-rich phosphate bond, taken as 10 kcal., as corresponding to a wave-length of 2–3μ in the near infra-red. Modern measurements give it as nearer 6 kcal. and therefore in the range of 5–6μ, even farther in the infra-red. However, he does not expect these bonds to be stimulated directly by visible light, which has a far higher energy, but only through some intermediate mechanism.

So far Szent-Györgyi has followed fairly straightforward quantum chemical lines. He breaks new ground, however, by associating the conditions of triplet excitations and energy-transfer with the properties of water or, more particularly, of ice. He describes a series of beautiful qualitative experiments by which the fluorescence of certain dyes and certain biologically active substances has profoundly altered the freezing of the water in which they are dissolved. Ordinary freezing is less effective than sudden deep freezing in 'dry ice'. As, however, he carefully states that these effects are spoilt by substances such as glycerol, which prevent ice crystallizing, it is difficult to see that he is doing anything other than studying the reactions of such molecules expelled from the solution on the formation of ice crystals. It may be, however, that they are actually incorporated in the ice-crystal structure, but this would require more proof than he provides.

As he says himself, "when considering water structures we enter fantastic and fascinating worlds". It is certain that the experiments described here deserve to be taken up again under controlled conditions to find out what produces the large effects that he has observed. In any event, they are worth while in directing attention to the states of aggregation of water in biological systems, especially at low temperatures, of which the remarkable work of Dr. B. J. Luyet has shown the degree of complexity. Szent-Györgyi himself now tends to turn to water to explain a number of phenomena where previously attention had been devoted to the more purely biological structures such as myosin, particularly the role of bound water on the surface of protein and other intracellular micelles.

Szent-Györgyi heads the second part of his work on biological structures and functions with the remark, "Research is to see what everybody has seen and to think what nobody has thought". Earlier he says: "The more we learn about myosin the less we understand it, which suggests we are looking at it in the wrong way". In this section he turns to the structure of the water outside the muscle, which after all makes up more than 80 per cent of its weight, to set the picture to rights. He uses this concept not so much to explain the contraction of muscle but, in his characteristically upside down way, to explain the relaxation of muscle. As he says, "the problem of contraction is not what makes the particle shorten but what keeps them extended when at rest, or stretches them out again after contraction". This he explains by a kind of crystallization of the water in the immediate contact with myosin particles.

There follows a discursive but most suggestive account which links this with the action of adenosine triphosphate in other systems, and much complex biochemistry concerned with the various types of interference with energy transfers, for example, that produced by 2 : 4 dinitronaphthol or by iodine. There is no space here to go into the whole of the numerous fascinating suggestions he makes covering the whole range of biochemical and physiological phenomena. For example, he discusses the action of the drug chlorpromazine in the treatment of schizophrenia, provides an explanation of myotonia in relation to the action of the drug 2 : 4 dichlorphenoxy acetic acid which artificially produces the same symptoms, and in general discusses the whole question of health and disease right down to "oxidation, fermentation and cancer" in the last chapter.

On almost every page there is some idea worth thinking about and worth starting some new experiments to prove or disprove. It is a book which will inspire many and infuriate some. To quote Belloc's preface to "Ruthless Rhymes", "And is this true? It is not true, And if it was, it would not do". Or rather, it does not matter. In the present revolutionary state of biochemistry, such challenging ideas may be more important than carefully checked measurements of unimportant phenomena.

J. D. Bernal

A HUNDRED YEARS OF CHEMICAL INDUSTRY

The Chemical Industry during the Nineteenth Century

A Study of the Economic Aspect of Applied Chemistry in Europe and North America. By Dr. L. F. Haber. Pp. x+292. (Oxford: Clarendon Press; London: Oxford University Press, 1958.) 45*s*. net.

THERE is no more rewarding background study for a young man entering the chemical industry than the history of its development during the past hundred years or so. The research chemist will learn much from the successes and failures of his predecessors. Almost unconsciously he will acquire a sense of scale and a perception of values which will help him to relate the worth of his individual work to the future prosperity and expansion of the industry in which he is engaged. The young plant manager will derive encouragement from the accounts of the start of new processes and of operating difficulties successfully overcome by resourceful engineering. A study of the rise and fall of varying methods of manufacture due to different raw materials, different chemical efficiencies and the changing requirements of customers cannot fail to stimulate interest in the economic prosperity of the process he is operating or developing.

The publication of Dr. L. F. Haber's book, "The Chemical Industry during the Nineteenth Century" is therefore to be warmly welcomed.

The book is a mine of detailed information and the accuracy is of a high order. Particularly valuable for the student are the ample footnotes with their references to the original sources. The compilation of the book must have involved the author in an immense amount of devoted labour.

It is not, however, very easy reading, partly on account of the number of detailed facts, some of which, though interesting in themselves, are to a certain extent irrelevant to the main themes of the book, but also because of the rather curious division of the chapters. Some of them deal with special topics, such as "New Schools of Science", "New Technologies" and "The Workers in the Nineteenth Century Chemical Industry", over the whole of the period under review, whereas others deal with the history of such processes as Leblanc soda manufacture and the ammonia–soda process in sections divided into arbitrary periods of time which have no special relation to technical changes or commercial competition. The author, in his introduction, rightly emphasizes the great interest of the changing role of the Leblanc soda trade, but in the book the story is cut into half a dozen sections unrelated except by a certain degree of repetition.

It would be of great interest to the student if the author, at some future date, could write the fascinating story of the development of the alkali industry as a thesis in itself. The main facts and factors involved are already in the present book, but their presentation as a continuous story would bring out far more clearly the reasons for the decline and fall of the Leblanc process and the technical and economic changes behind it.

The chemical industry exists primarily to serve the raw material requirements of other industries. As the standard of living increases, so does the extent and prosperity of consumer industries grow. The chemical industry grows with them.

In the nineteenth century, the remarkable increase in the textile industry in the United Kingdom, and to a lesser extent in the production of glass, paper and soap, brought with it a rapidly increasing demand for soda ash, for bleach, for sulphuric acid and for saltcake. It is difficult to realize to-day that in the decade 1870–80 the demand for bleaching powder, owing to the enormous size of the cotton textile industry, was nearly as big as the demand for soda ash. It was for this reason that, in spite of the chemical elegance of the ammonia–soda process and the great technical advantage of a continuous process as opposed to the batch working of the Leblanc manufacturers, Brunner Mond and Co. were forced to make chlorine and bleaching powder from the liquor of the ammonia–soda process. The daring and technically successful achievement of Dr. Mond in producing chlorine from ammonium chloride (incorrectly described as "calcium chloride" on p. 159) by vaporizing it and passing it over nickel oxide pills was costly, but it served its commercial purpose by preventing the Leblanc manufacturers from increasing the price of bleach and selling soda ash as a by-product at give-away prices. The interesting graph of bleaching powder prices in Appendix 5 illustrates this well.

The sections of the book dealing with the development of the dyestuffs industry make interesting reading, though here again the story suffers from a certain lack of continuity which makes it difficult to follow the economic factors involved.

The chapter entitled "Chemical Manufacturers and their Problems" gives a number of tables illustrating movements in international trade in chemicals and directs special attention to the effect of tariff changes. A particularly vivid example which is quoted is that of the Dingley tariff in the United States. Until the early 'nineties, the United States was by far the most important export market for British alkali manufacturers, taking the enormous quantity of more than 150,000 mixed tons. Within a year or two of the imposition of the tariff, British exports had diminished to a mere trickle.

J. L. S. STEEL

THE STATISTICAL DESCRIPTION OF VEGETATION

Quantitative Plant Ecology

By P. Greig-Smith. Pp. ix+198. (London: Butterworths Scientific Publications; New York: Academic Press, Inc., 1957.) 30*s*.; 6 dollars.

THIS book deals primarily with some of the statistical approaches to the problems of describing the distribution of vegetation and, in a few cases, of species. The basis of these techniques involves concepts such as those of density, frequency and cover, which are first explained and then used to introduce the principles involved in sampling, the arrangement and size of the units of estimation and the comparison of the results of different sets of observations. A considerable part of the book is devoted to the analysis of what is called 'pattern' in vegetation—defined as the departure from randomness of distribution of individuals within the plant community—and then to the possible relationships between the patterns shown by different species and their correlation or lack of correlation in distribution. Finally, consideration is given to the possibility of

delimiting plant communities on purely objective grounds and the bearing of this upon the classification of vegetation.

Although one chapter gives examples of correlations between vegetation and the level of environmental factors, the book is not primarily concerned with ecology in the usual sense of the word—the relation between organisms and their environment—or with the quantitative study of these relations as estimated, for example, by weighing, counting or measuring. To this extent the title is a misnomer. It is, indeed, in the reviewer's estimation the only part of the book open to real criticism.

Although ecologists dealing with vegetation have usually accepted the simplest descriptive units which could be clearly defined (hence often a species) as the quantitative basis for correlations between vegetation and environment, most of them at some time have also wished for larger units with objective biological significance. Long ago this was the initial attraction of the methods of the Upsala school, though in that case, as so often since, the hope was soon dispelled. This ideal the author of this work keeps clearly in mind and the great merit of the book is that it discusses at frequent intervals the basic problems which have to be faced in arriving at suitable underlying concepts. It indicates how, in the author's opinion, solutions might be found. While the reader may find himself at times unable to agree with the author, he will certainly also find the discussions thoughtful and stimulating, though, as is often the case in such matters, it is not possible to convey their interest in a short review.

This is a useful and timely book : useful, because it collects most of the pertinent arguments and statistical methods in one volume ; timely, because it tries to integrate the large recent accessions of literature in this field and also because it presents and unifies ideas and thus will undoubtedly form a basis for further advances.

W. H. Pearsall

SCIENCE FOR STUDENTS OF THE HUMANITIES

Harvard Case Histories in Experimental Science

Edited by James Bryant Conant and Leonard K. Nash. Vol. 1. Pp. xvi+322. Vol. 2. Pp. v+323–639. (Cambridge, Mass. : Harvard University Press ; London : Oxford University Press, 1957.) 80*s*. net the set.

THE case histories in experimental science introduced to Harvard by J. B. Conant have become widely known as representing an interesting experiment in the teaching of science to non-scientists. The collection of eight of these case histories into two volumes, under Conant's editorship, has now made them easily available to English readers. The 'cases' are concerned with : Boyle's experiments in pneumatics ; the overthrow of the phlogiston theory ; the early development of the concepts of temperature and heat ; the atomic–molecular theory ; plants and the atmosphere ; Pasteur's study of fermentation ; Pasteur's and Tyndall's study of spontaneous generation ; the development of the concept of electric charge.

Each 'case' is in the form of a self-contained essay aimed at bringing the reader into the frame of mind of the earlier experimenters and at showing him how difficult it often was for investigators to make a break with tradition and to start thinking along new lines. It is shown how the change in point of view depended jointly on experimentation and on imaginative conjecture, and how the approach was seldom direct, but when seen from our more enlightened point of view seems often to have been roundabout and tortuous. To bring the reader more closely into contact with the mental attitude of the original investigators, skilful use is made of quotations from original papers.

It is difficult for a scientist to assess how far a non-scientist would find these essays interesting or instructive. For that it is best to rely on experience in the United States, where, at Harvard and elsewhere, they have been highly successful, in the hands of skilled teachers, in transmitting something of the principles of scientific investigation to those whose main studies were in the humanities.

To a scientist, however, there is no doubt at all that the essays provide an excellent account of how a series of discoveries came about, and the reader finds himself sharing in the excitement of the early investigators. Most scientists will find much that is new, even in the history of their own subject. I learnt for the first time, for example, how Hauksbee's experiments led him by curiously devious routes from the study of the flash of light which sometimes occurs in the space above the mercury when a barometer tube is shaken, to the discovery of several new phenomena in electrostatics and, in particular, to that of electrostatic induction.

Most degree courses in science are so concerned with imparting the maximum of 'useful' knowledge that neither teachers nor learners often find time to inquire just how some of the concepts they take for granted really arose. It is difficult to avoid being swept along with this rushing stream of education and discovery ; but if it is to be education in the true sense, and not just the acquiring of technical knowledge which will 'work' when one has to solve a problem, it is necessary to pause at intervals and ask how some of our present-day scientific concepts first arose.

These volumes will provide quiet backwaters into which the research worker or teacher can turn and linger for a short time to study what has happened to the streams of discovery before he joined it, and before he joins it again in his headlong rush to make those advances in knowledge which will form the subject of 'case histories' in the future.

J. A. Ratcliffe

THEORETICAL OPTICS

Geometrical and Physical Optics

By Dr. R. S. Longhurst. Pp. xvi+534. (London and New York : Longmans, Green and Co., Ltd., 1957.) 60*s*. net.

WITHOUT necessarily asking too much from the reader of limited mathematical attainment, Dr. Longhurst has given a most comprehensive account of geometrical and physical optics at degree standard which should be widely welcomed. For the pass or general degree student, the treatment is taken as far as possible along elementary lines. The more difficult mathematical work is grouped into separate sections, for those who have to read more deeply ; and modern experimental work, and practical applications of optical techniques, are discussed

at a level which should prove both helpful and stimulating to the more advanced student who may later specialize in optics.

The first five chapters deal with the general geometrical theory of the perfect image-forming optical system, the paraxial theory of optical instruments, the determination of the constants of optical systems, and the use of the prism in refractometry and spectroscopy. Next, the mathematical treatment of the wave equation, and the ideas of coherence and wave and group velocity, introduce the wave theory of light. Three chapters on interference follow—treating the interference of two beams by wave-front division, that of two beams by amplitude division, and multiple-beam interferometry. Chapter 10, after a critical discussion of Fresnel's theory of diffraction, deals fully with Kirchhoff's diffraction formula, and then explains the basis on which diffraction patterns are classified as 'Fresnel' or 'Fraunhofer'. Chapter 11, on the single slit, and Chapter 12, on diffraction gratings, between them cover all aspects of Fraunhofer diffraction. Chapter 13 deals separately with the Fresnel type. It is usual (and indeed essential if they are to be intelligible) to dissect interference and diffraction effects in this manner, but it is rarely so constructively done; and it is a great assistance to find practical applications such as the Twyman-Green interferometer, the wave-front shearer, and the Sears-Barrell length-standard work, classified likewise under the appropriate heading.

Chapters 15 and 16 discuss the aberrations of lenses, the means of controlling them in optical systems, and a number of standard lens combinations. The chapter on visual optics deals also with colour; that on photometry is chiefly concerned with standards and with visual photometry. The final chapters deal with the electromagnetic theory, the propagation of light in crystals, optical activity, and the velocity of light. Much has been done since R. T. Birge's review of this last subject in 1941, and a good account of the work up to 1957 is given here.

This last comment summarizes one quite striking feature of the book; that it is the work of an enthusiast who would have his students well informed on current progress. But the whole is unusually well planned for its purpose, from the patient sorting out of the sign convention at the beginning to the arrangement of the severer mathematics for "omission at a first reading"; it is a really excellent book. Dr. Longhurst, in the preface, calls it "a student's textbook". This it most certainly is, but there must be many people well past their student days who will find it to be a valuable work of reference.

G. R. Noakes

HISTORY OF IRON IN BRITAIN

History of the British Iron and Steel Industry from c. 450 B.C. to A.D. 1775

By Dr. H. R. Schubert. Pp. xxi+445+26 plates. (London: Routledge and Kegan Paul, Ltd., 1957.) 60*s*. net.

TOWARDS the end of the fifteenth century a technological discovery was made which revolutionized the iron industry and was, in fact, the harbinger of our modern civilization. From the very beginning of the Iron Age this metal had been produced by the direct reduction of the ores in furnaces of small size in which the temperature normally never attained that required for fusion, though it is certain that on occasion and by accident the sponge iron produced became carburized to such an extent that a molten product—white cast iron—was obtained. As the size, and particularly the height, of the furnace in which the reduction was effected was increased, higher and higher temperatures were attained until, finally, the forerunner of the modern blast-furnace was developed and molten iron was produced deliberately. This great change in technique resulted in a relatively enormous increase in output. It further provides the justification for the division of this really important contribution to the history of technology into two parts, the first concerned with the early history of a process which resulted in a soft sponge iron, the latter in the production of molten cast iron, used at first mainly for the production of military castings, which required a second process for its conversion into a malleable product.

The author, a professional historian, surveys the whole history of the industry from the first introduction of iron to Britain to the time when molten steel was produced commercially by the Huntsman process; but nowhere is his background shown to better advantage than in the skill with which he has revealed the extent to which the introduction of the blast-furnace increased the output of metal obtained. In the course of a few decades the daily output per furnace was raised some seven times. The wide field over which the material has been collected and the great skill with which it has been sifted and woven into a surprisingly coherent story deserve the highest praise.

Of the earliest English blast-furnaces neither picture, description nor remains have been preserved: the furnace, previously supposed to be of this nature, from a drawing in the Public Record Office, was, in fact, a lead furnace erected in Derbyshire about 1552. It is, therefore, from the accounts of the Sussex ironworks, from 1541 onwards, that it has been possible to obtain some idea of the structure as it existed in the early sixteenth century, and the author has been able to reconstruct the main outlines of this piece of equipment, a description which is rendered the more vivid from the excellent coloured frontispiece of a painting by the Flemish artist, Blès.

There are certain minor imperfections in the text: W. Goland of Appendix 1, for example, should surely be Prof. W. Gowland, and that the author is not himself a metallurgist is here and there apparent. It is this fact, presumably, which leads him to perpetuate the heresy that there was some special virtue or magic in ores containing small amounts of manganese and titanium which rendered it possible for primitive metallurgists to produce a steel, as distinct from soft iron, in the early direct furnace. It is quite easy to do this even in the complete absence of either of those elements by allowing the reduced sponge to remain in contact for a sufficient time with the glowing charcoal.

Despite such blemishes, however, there can be no question that the volume under consideration is one of quite outstanding merit, for which the archæologist and technologist alike owe a very deep debt to the author himself and to the Iron and Steel Institute, through the support of which the researches here recorded were carried out.

F. C. Thompson

Nuclear Engineering

Edited by Prof. Charles F. Bonilla. (McGraw-Hill Series in Nuclear Engineering.) Pp. xi+85 (London: McGraw-Hill Publishing Company Ltd., 1957.) 94*s*.

TWELVE specialists have collaborated in writing this book. Of the 800 pages, 170 are devoted to nuclear physics and associated subjects, 100 to reactor physics and shielding theory, about 300 to thermal and structural considerations, about 60 to instrumentation and less than 20 to metallurgy.

Although the nuclear physics is well presented, a more rigorous selection of topics with greater emphasis on those of immediate importance would have pleased the reviewer. There is a well-written chapter on radiation protection, which includes a clear explanation of the units used, the variety of which usually bewilders students.

Reactor physics is not allotted enough space and too much is attempted in the space available. In covering neutron cycles, flux, extrapolation distance, one group, multigroup and age theories, and resonance absorption effects, as well as discussing transport and diffusion theories and other topics in the space of 30 pages it has only been possible to survey the subject.

The real value of the book lies in its treatment of thermal and structural aspects of reactors, and for this section it can be recommended. There is a stimulating discussion of the potentialities and problems of non-elastic design methods.

Concluding chapters deal with reactor types and legal aspects of nuclear power.

As a text-book it suffers from having too many authors; as a work of reference its value is enhanced by the many references included, particularly on heat transfer, but weakened by an inadequate index.

W. Murgatroyd

A Revision of the Australian Chafers (Coleoptera: Scarabaeidae: Melolonthinae)

By E. B. Britton. Vol. 1. Pp. viii+186+42 plates. (London: British Museum (Natural History), 1957.) 80*s*.

IT is now generally recognized that an effective investigation into the biology and control of any group of animals must be based upon a sound taxonomy, but all too frequently this basic requirement remains unfulfilled until a very late stage, when already much effort has been wasted because of faulty identification. In the present volume the systematics of an important group of beetles is placed upon a satisfactory footing in a comparatively early stage of the investigation. The damage done by the Melolonthinae as a whole is of considerable economic importance, and it is chiefly due to the root-feeding habits of the larvæ. A great variety of plants are attacked by one or other of the species: grasses and various field crops including maize and sugar cane and also vegetables and fruit. Sometimes a considerable amount of damage is done by the adults of some species that feed upon the leaves of shade and fruit trees and also injure vines. It is somewhat surprising to find that all the pest species are indigenous, as indeed are all other Melolonithinae of Australia.

The volume is exceptionally well illustrated; there are 524 figures of which all but 25 drawings of the whole insect are arranged in 42 plates at the end. Most of the figures are simple but good outline drawings of the male genitalia and of the head and prothorax of the different species. The keys are well done in the best modern style, and there would seem to be no difficulty in choosing between the alternatives offered in each couplet. Thirteen tribes are recognized of which no less than ten are described as new. The Sericini and four of the new tribes are dealt with in this first volume. These five tribes include 203 species of which 67 are described for the first time.

H. E. Hinton

Fibre Microscopy

Its Technique and Application. By Dr. J. L. Stoves. Pp. viii+276. (London: National Trade Press, Ltd., 1957.) 50*s*. net.

SO much is the make-up of all biological tissues of a fibrous construction, so much does man put numerous animal and vegetable fibres to supplementary uses, and so much has he now extended the idea into similar fields more purely of his own invention, that there is a continual need for good and up-to-date writing on the subject, and a new book of the kind on fibre microscopy can scarcely fail to be most acceptable to all sorts of readers. Dr. Stoves, out of his wide experience and contacts in such matters, has certainly provided one in the volume noticed here, directed to "students, laboratory assistants, analysts and research workers"—and that means, among many others, archæologists and criminologists, for example; and he has spread its informative coverage over all the latest developments, including, of course, phase-contrast, interference and reflexion microscopy and, of ever-growing importance these days in spite of the expense, electron microscopy (plus, it should be mentioned, a chapter on metal shadow-casting in visible microscopy). He applies them then to the examination of almost anybody's fibres, so to speak. There are also excellent bibliographies and suggestions for further reading, indexes of animals and plants, and lists of stains and staining reactions. Altogether, this is a very worthwhile book indeed.

W. T. Astbury

Bakteriophagie 1917 bis 1956

Zugleich ein Vorschlag zur Dokumentation wissenschaftlicher Literatur. Von. Dr. Hansjürgen Raettig. Teil 1: Einführung—Sachregister—Stichwortverzeichnis. Pp. xix+215. Teil 2: Autorenregister. Pp. iii+344. (Stuttgart: Gustav Fischer Verlag, 1958.) 44 D.M.

THESE two little books are intended as a guide to the literature on bacteriophage published between 1917 and 1951; they are a monument to German industry and thoroughness. Vol. 2 lists under authors no less than 5,655 references. Looking up fifty references, some of them from rather obscure journals, failed to reveal one which was not listed, and quite a large number from Russian journals are included. Vol. 1 classifies the material under subjects; here the arrangement is good but not perfect. A few omissions were detected: for example, *Escherichia* is unaccountably missing on p. 137. The books suffer, as do most bibliographies, from the defect that one cannot tell which of the many references are the really important ones.

The format is excellent; the limp covers in an attractive blue-grey add to the appeal of the volumes. Anyone who has to write an article, a review or even a book on phage will find that Dr. Hansjürgen has saved him much of his labour.

C. H. Andrewes

SEPARATION OF LIGHT AND DARK PHASES IN THE PHOTOSYNTHESIS OF ISOLATED CHLOROPLASTS

By Dr. ACHIM V. TREBST, HARRY Y. TSUJIMOTO and Prof. DANIEL I. ARNON
Laboratory of Plant Physiology, Department of Soils and Plant Nutrition, University of California, Berkeley

THE recognition of a 'dark', that is, a thermochemical phase in photosynthesis, had its origin in Blackman's findings[1], that at high, but not at low, light intensities the rate of photosynthesis is dependent on temperature. Warburg named this thermochemical stage of photosynthesis the Blackman reaction and established its sensitivity to cyanide[2]. The present communication reports the physical separation, by fractionating chloroplasts, of the light and dark phases of photosynthesis. The light phase was completed first and was then followed by the dark phase. The two phases, when carried out consecutively, yielded essentially the same final photosynthetic products as the continuously illuminated complete chloroplast system.

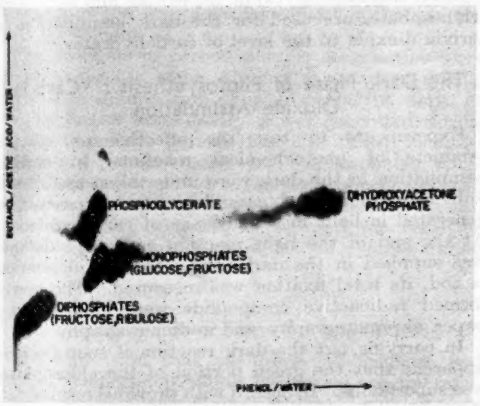

Fig. 1. Radioautograph of a chromatogram showing products of photosynthetic $^{14}CO_2$ assimilation by illuminated chloroplasts. Experimental conditions as in treatment 3 of Table 1

It has recently been shown that the organization of the living cell is not necessary for photosynthesis as it is usually defined[3]. Reduction of carbon dioxide to carbohydrates accompanied by oxidation of water to oxygen is carried out, at low temperatures and with no energy supply except visible light, by isolated chloroplasts, unaided by other cellular particles or enzyme systems[4–12,13–15].

This extracellular photosynthesis by chloroplasts differs from that process in whole cells notably in that it proceeds independently of concurrent cellular activities, such as respiration, which cannot be divorced from photosynthesis in intact cells[16]. Isolated chloroplasts, if freed from other cytoplasmic impurities, do not respire[6,10,17]—a conclusion which has recently received strong support from the work of James and Das[18]. The products of photosynthesis by isolated chloroplasts are mainly carbohydrates; amino-acids were not formed in the experiments reported here (Figs. 1, 2, 3). The role of amino-acids in photosynthesis has assumed special interest in the light of Warburg's[19] recent findings with *Chlorella* cells.

Although extracellular photosynthesis by chloroplasts cannot be equated in all respects with photosynthesis in intact cells it retains the principal features of that process, and permits their investigation in isolation from concurrent cellular activities. The separation of photosynthesis by chloroplasts from the structural and functional complexity of the

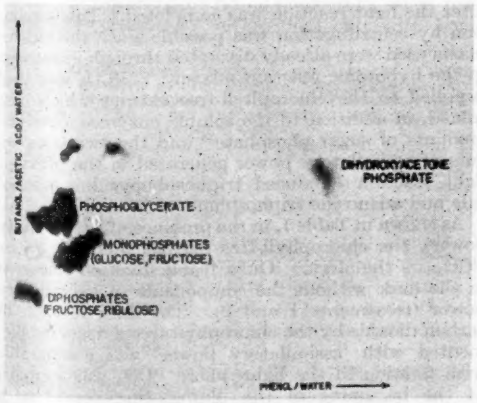

Fig. 2. Radioautograph of a chromatogram showing products of dark $^{14}CO_2$ assimilation by a chlorophyll-free extract of chloroplasts, supplemented with 'assimilatory power' formed in a previous light reaction. Experimental conditions as in treatment 1 of Table 1

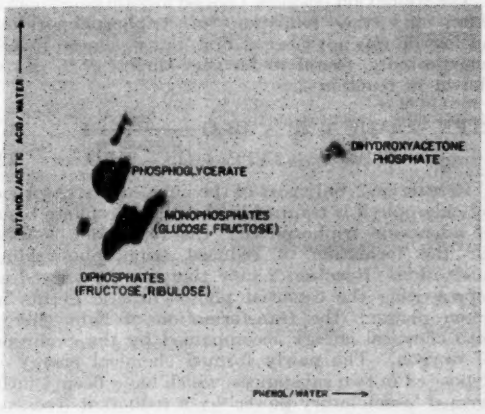

Fig. 3. Radioautograph of a chromatogram showing products of dark $^{14}CO_2$ assimilation by a chlorophyll-free extract of chloroplasts supplemented with adenosine triphosphate, and reduced triphosphopyridine nucleotide formed by the oxidation of isocitrate. Experimental conditions as in treatment 9 of Table 3

whole cell has provided a particularly useful approach to the study of those problems in photosynthesis in which a clear distinction from the dark reactions of respiration is especially pertinent. One of these problems is the relation between the light and dark reactions in photosynthesis.

The Photochemical Phase of Photosynthesis: Oxygen Evolution and the Generation of Assimilatory Power

Systematic studies of the photochemical reactions of isolated chloroplasts, without the participation of carbon dioxide, began with the experiments of Hill[20] in 1937. Recent progress which led to the characterization of the physiological products of these reactions came from two directions: the finding of a photochemical phosphorylation system in chloroplasts[21] and, as will be discussed next, the identification of the reductant for the assimilation of carbon dioxide.

Vishniac and Ochoa[22], Tolmach[23], and Arnon[24] found that, in light, isolated chloroplasts can reduce pyridine nucleotides and simultaneously evolve oxygen, if this photochemical reaction is coupled with an enzyme system capable of utilizing the reduced pyridine nucleotides. A direct reduction of pyridine nucleotides by illuminated chloroplasts, as measured by the accumulation of the reduced product, was demonstrated by San Pietro and Lang[25]. Evidence has also been obtained that triphosphopyridine nucleotide rather than diphosphopyridine nucleotide is preferentially reduced in light[26,27].

Another photochemical process occurring in isolated chloroplasts is photosynthetic phosphorylation, that is, the utilization of light energy for the synthesis of high-energy phosphate bonds in accord with the overall reaction 1, where P represents orthophosphate and ADP and ATP represent adenosine diphosphate and triphosphate, respectively.

$$n.\mathrm{ADP} + n.\mathrm{P} \xrightarrow[\text{chloroplasts}]{\text{light}} n.\mathrm{ATP} \qquad (1)$$

In reaction 1, all the captured light energy is converted into the high-energy pyrophosphate bonds of adenosine triphosphate. This type of photosynthetic phosphorylation has been named cyclic photophosphorylation[21].

The connexion between photosynthetic phosphorylation and the reduction of triphosphopyridine nucleotide was not clear at first, but was later, rather unexpectedly, found to be very direct[21,26,28]. It is shown in reaction 2.

$$2\mathrm{TPN} + 2\mathrm{ADP} + 2\mathrm{P} + 4\mathrm{H_2O} \xrightarrow[\text{chloroplasts}]{\text{light}} 2\mathrm{TPNH_2} + 2\mathrm{ATP} + \mathrm{O_2} + 2\mathrm{H_2O} \qquad (2)$$

In reaction 2, only part of the light energy absorbed by chlorophyll is trapped in the pyrophosphate bond of adenosine triphosphate; the remainder is used for the formation of reduced triphosphopyridine nucleotide. Reaction 2 may therefore be viewed as representing the essential photosynthetic events in green plants: the transformation of light energy into chemical energy accompanied by the evolution of oxygen. The newly formed chemical energy is deposited in two substances, which have been jointly termed 'assimilatory power'[21]: a reductant (reduced triphosphopyridine nucleotide) and an energy-rich phosphorus compound (adenosine triphosphate).

The stoichiometry of reaction 2, when measured under appropriate experimental conditions[21,26,28], indicates that the formation of four hydrogen equivalents, needed for reduction of one mole of carbon dioxide to the level of carbohydrate (= CH.OH), is accompanied by the evolution of one mole of oxygen, as would be expected from the well-known photosynthetic ratio CO_2/O_2 of 1. In addition, two moles of adenosine triphosphate are formed. Whether these fulfil the requirements for adenosine triphosphate in the assimilation of carbon dioxide cannot as yet be stated with certainty[12]. If, however, reaction 2 cannot by itself supply enough adenosine triphosphate for carbon assimilation then it could be supplemented, to a varying degree, by cyclic photophosphorylation (reaction 1).

To recapitulate, it is envisaged that in photosynthesis by isolated chloroplasts the photochemical events are the evolution of oxygen coupled with the generation of 'assimilatory power' (reaction 2), and cyclic photophosphorylation (reaction 1). It is assumed that the cell has suitable regulatory mechanisms for maintaining a balance between these two reactions[21]. What remains to be demonstrated is that the products of these photochemical reactions, reduced triphosphopyridine nucleotide and adenosine triphosphate, are used for the dark assimilation of carbon dioxide to the level of carbohydrates.

The Dark Phase of Photosynthesis: Carbon Dioxide Assimilation

Experiments to test the effectiveness of the products of photochemical reactions in carbon assimilation in the dark were undertaken as follows. Substrate amounts of 'assimilatory power' were first generated in light in the absence of carbon dioxide. At the end of the light reaction carbon-14 dioxide was supplied in the dark, and, after an incubation period, its total fixation was measured. The newly formed radioactive compounds were identified by paper chromatography and radioautography[7].

In carrying out the dark reaction it soon became apparent that the green portion of the chloroplasts was superfluous. In accord with previous results[8,9,11], the chloroplast enzymes responsible for carbon assimilation were present in the chlorophyll-free, water-soluble portion of the chloroplasts ('stroma'). The water-insoluble green portion of the chloroplasts ('grana') was therefore removed by centrifugation after the light reaction was completed. This separation by centrifugation was possible since the chloroplasts used were already disrupted through immersion in the hypotonic reaction mixture. $^{14}CO_2$ was then supplied to the chlorophyll-free extract which contained, in addition to the soluble enzymes, catalytic amounts of sugar phosphate[11] and the two components of assimilatory power generated in the previous light reaction: reduced triphosphopyridine nucleotide and adenosine triphosphate.

As shown in Table 1, in the presence of 'assimilatory power', the chlorophyll-free extract was able to fix $^{14}CO_2$ in the dark. Only feeble fixation occurred in the dark without the components of assimilatory power (treatments 1 and 2). The dark fixation of carbon dioxide by the chlorophyll-free extract supplemented with 'assimilatory power' was comparable with fixation in the light where $^{14}CO_2$ was supplied at the beginning of the illumination period to a reaction mixture containing the complete chloroplast system. Here 'assimilatory power' was formed continuously in the light and used at once for carbon dioxide fixation (treatment 3). Very little fixation

Table 1. Carbon Dioxide Fixation by a Chlorophyll-free Extract and a complete Chloroplast System from Spinach

Treatment	$^{14}CO_2$ fixed (counts/min.)
1. Chlorophyll-free extract, dark + A.P.*	134,000
2. Chlorophyll-free extract, dark − A.P.*	9,000
3. Complete chloroplast system, light	200,000
4. Complete chloroplast system, dark	20,000

* A.P. = Assimilatory power, that is, reduced triphosphopyridine nucleotide and adenosine triphosphate formed in light by chloroplasts. The complete chloroplast system contained in a final volume of 2·5 ml. 'broken' chloroplasts (ref. 12) containing 0·5 mgm. chlorophyll, chlorophyll-free extract (ref. 12) equivalent to 2 mgm. of chlorophyll and the following in micromoles: *tris* (hydroxymethyl) aminomethane buffer, *p*H 7·5, 80; magnesium chloride, 5; manganese chloride, 2; sodium ascorbate, 10; glucose-1-phosphate, potassium salt, 0·3; sodium phosphate *p*H 7·5, 5; adenosine diphosphate, 2; and triphosphopyridine nucleotide, 2. The reaction was carried out at 20° C. for 30 min.; gas phase, argon. In treatments 3 and 4, 10 micromoles sodium bicarbonate, containing $^{14}CO_2$, were injected at the beginning and the reaction vessels were illuminated or left in the dark, respectively. In treatment 1, the reaction mixture was first illuminated without the addition of bicarbonate. After 30 min., the particles containing chlorophyll were removed by centrifugation, and the chlorophyll-free supernatant fluid was incubated in the dark for 30 min. with 1·5 micromoles cystein and 10 micromoles of sodium bicarbonate containing $^{14}CO_2$. The same procedure was followed in treatment 2 as in treatment 1 except that adenosine diphosphate and triphosphopyridine nucleotide were omitted.

occurred in the complete chloroplast system in the dark (treatment 4).

The products of carbon dioxide assimilation were found to be the same whether it occurred during continuous illumination (Fig. 1) or in the dark, at the expense of assimilatory power generated during a preceding light period (Fig. 2). They included hexose and pentose mono- and di-phosphates, phosphoglyceric acid, dihydroxyacetone phosphate, and small amounts of phosphoenolpyruvate and malate.

Carbon dioxide fixation in the dark was sensitive to cyanide. The inhibition at 10^{-3} *M* cyanide varied between 60 and 80 per cent.

Assimilatory Power from Outside Sources

The conclusion that adenosine triphosphate and reduced triphosphopyridine nucleotide are the components of assimilatory power required by chloroplast enzymes for carbon dioxide assimilation was tested by supplying these substances, in substrate quantities, from external sources instead of generating them in a light reaction. The results are shown in Table 2.

Reduced triphosphopyridine nucleotide, when prepared either chemically, or enzymatically with isocitric dehydrogenase, was, in combination with adenosine triphosphate, as effective in bringing about carbon dioxide assimilation by the chlorophyll-free extract of chloroplasts as the 'assimilatory power' generated by illuminated chloroplasts. The omission of reduced triphosphopyridine nucleotide or its substitution by reduced diphosphopyridine nucleotide cut carbon dioxide fixation approximately in half. No significant fixation occurred when both reduced triphosphopyridine nucleotide and adenosine triphosphate were absent.

In the dark fixation experiments described so far, reduced triphosphopyridine nucleotide was supplied in substrate quantities, since no provision was made for its regeneration, as would be the case with illuminated chloroplasts. However, carbon dioxide assimilation in the dark also proceeds with a catalytic amount of reduced triphosphopyridine nucleotide if its supply is maintained by an enzymatic reaction catalysing a triphosphopyridine nucleotide-dependent oxidation of an appropriate substrate. Parallel experiments have shown that in addition to the enzymes previously identified[8,9,11], the chlorophyll-free extract of chloroplasts contained glucose-6-phosphate dehydrogenase, 6-phosphogluconic acid dehydrogenase and isocitric dehydrogenase which catalyse, respectively, reactions 3, 4 and 5[29,30].

$$\text{Glucose-6-phosphate} + \text{TPN} \longrightarrow \text{6-phosphogluconate} + \text{TPNH}_2 \quad (3)$$

$$\text{6-Phosphogluconate} + \text{TPN} \longrightarrow \text{ribulose-5-phosphate} + CO_2 + \text{TPNH}_2 \quad (4)$$

$$\text{D-Isocitrate} + \text{TPN} \xrightarrow{Mn^{++}} \alpha\text{-ketoglutarate} + CO_2 + \text{TPNH}_2 \quad (5)$$

Table 3 shows that catalytic amounts of reduced triphosphopyridine nucleotide (0·3 micromole) generated *in situ* by the oxidation of one of three substrates, glucose-6-phosphate, 6-phosphogluconic acid or isocitric acid, were, in combination with adenosine triphosphate, as effective for carbon dioxide assimilation in the dark as substrate amounts of reduced triphosphopyridine nucleotide (2 micromoles) used in previous experiments (Tables 1 and 2). Carbon dioxide fixation was greatly diminished by omitting

Table 2. Carbon Dioxide Fixation in the Dark by a Chlorophyll-free Extract of Chloroplasts, supplemented with Adenosine Triphosphate (ATP) and Reduced Triphosphopyridine Nucleotide ($TPNH_2$) of Photosynthetic and Non-photosynthetic Origin

Treatment	$^{14}CO_2$ fixed counts/min.
1. Chlorophyll-free extract + A.P.*	96,000
2. Chlorophyll-free extract − A.P.*	4,000
3. Chlorophyll-free extract + ATP†	43,000
4. Chlorophyll-free extract + (ATP† + $DPNH_2$‡)	59,000
5. Chlorophyll-free extract + (ATP† + $TPNH_2$§)	97,000
6. Chlorophyll-free extract + (ATP† + $TPNH_2$‖)	140,000

Treatments 2–6 were the same as treatment 2 in Table 1, except for the indicated additions.

* A.P. = Assimilatory power, that is, ATP + $TPNH_2$, formed in light by chloroplasts (see treatment 1, Table 1).
† Two micromoles (from animal sources, Sigma Chemical Co.).
‡ $DPNH_2$ = reduced diphosphopyridine nucleotide (2 micromoles) enzymatically prepared, Sigma Chemical Co.
§ 1·4 micromoles, enzymatically prepared with isocitric dehydrogenase. The enzyme itself was without effect on the course of the reaction.
‖ 2 micromoles, chemically prepared, Sigma Chemical Co.

Table 3. Carbon Dioxide Fixation in the Dark by a Chlorophyll-free Extract of Chloroplasts, supplemented with Adenosine Triphosphate (ATP) and Catalytic amounts of Triphosphopyridine Nucleotide (TPN) reduced at the expense of one of three Hydrogen Donors

Treatment	Hydrogen donor	$^{14}CO_2$ fixed (counts/min.)
1. Chlorophyll-free extract + TPN*	glucose-6-phosphate†	3,300
2. Chlorophyll-free extract + ATP†	,,	45,000
3. Chlorophyll-free extract + TPN* + ATP†	,,	171,000
4. Chlorophyll-free extract + TPN*	6-phosphogluconate†	7,200
5. Chlorophyll-free extract + ATP†	,,	17,000
6. Chlorophyll-free extract + TPN* + ATP†	,,	190,000
7. Chlorophyll-free extract + TPN*	Isocitrate‡	16,000
8. Chlorophyll-free extract + ATP†	,,	95,000
9. Chlorophyll-free extract + TPN* + ATP†	,,	292,000

* 0·3 micromole.
† 2 micromoles.
‡ 5 micromoles of isocitrate plus 2 micromoles of ribose-5-phosphate (R-5-P) were added.

Other experimental conditions as in treatment 2 of Table 1.

either adenosine triphosphate or triphosphopyridine nucleotide. Moreover, in the absence of reduced triphosphopyridine nucleotide little, if any, sugar phosphate was found among the products of fixation.

In the experiments represented by Table 3 photosynthesis has been replaced by a chemosynthesis in the sense that the reductant required for carbon dioxide assimilation by chloroplast enzymes was being continuously generated at the expense of a chemical hydrogen donor, a sugar phosphate or an organic acid, instead of light energy. As shown in Fig. 3, the products of this chemosynthesis by chloroplast enzymes are the same as those found during photosynthesis (Fig. 1).

In the present investigation, the chlorophyll-free extract of isolated chloroplasts was the source of all the enzymes required for the dark synthesis of phosphorylated sugars from carbon dioxide. Other cell-free systems have been described as models for photosynthetic carbon assimilation. Racker[31] used for the synthesis of hexose monophosphate a multi-enzyme system in which spinach leaves served as a source or the pentose cycle enzymes. These were supplemented[32] with glyceraldehyde-3-phosphate dehydrogenase and aldolase from rabbit muscle and phosphoglyceric acid kinase from yeast. The reductant was reduced diphosphopyridine nucleotide, rather than reduced triphosphopyridine nucleotide as in our experiments, and was generated either with molecular hydrogen and a diphosphopyridine nucleotide-linked hydrogenase from a bacterial source or with alcohol and an alcohol dehydrogenase from yeast. Fager[33] prepared from whole spinach leaves a protein fraction which fixed carbon dioxide not to the level of sugars but as phosphoglyceric and pyruvic acids. The rate of carbon dioxide fixation was increased when this fraction was illuminated in the presence of chloroplast fragments; in his system the addition of diphospho- or triphospho-pyridine nucleotides had no effect, whereas that of adenosine triphosphate was inhibitory to carbon dioxide fixation in both light and dark.

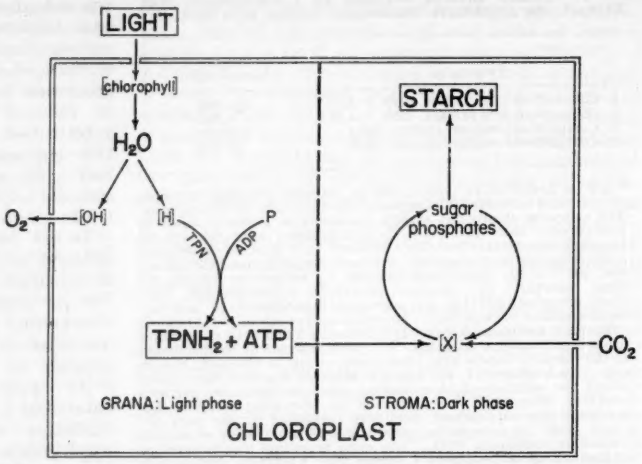

Fig. 4. Scheme for photosynthesis by isolated chloroplasts. In the light phase, photolysis of water, catalysed by 'grana', results in the evolution of oxygen and the generation of assimilatory power comprising two components: reduced triphosphopyridine nucleotide ($TPNH_2$) and adenosine triphosphate (ATP). In the dark phase, assimilatory power is used by the enzymes in the 'stroma' for the assimilation of carbon dioxide in reactions independent of light

General Considerations

In whole cells the light and dark phases of photosynthesis were investigated by techniques of intermittent illumination and experiments on induction phenomena[2,34–38]. Evidence began to accumulate[37,39,40], and was later strengthened by experiments with radiocarbon[41–45], in support of the view that carbon assimilation occurs during the dark phase of photosynthesis. Pre-illuminated cells retained for a short time, measured in minutes[42–44] or seconds[45], the ability to fix carbon dioxide afterwards in the dark. Benson and Calvin[42,43] interpreted this dark fixation as having been accomplished by a "reducing power" formed during the pre-illumination period, whereas Gaffron *et al.*[45] considered that pre-illumination produced an acceptor which was carboxylated during the dark carbon dioxide 'pick-up'. No experimental evidence was adduced in either case for the identity of the postulated short-lived product(s) of the photochemical reactions.

Photosynthesis by isolated chloroplasts was found to lend itself to a physical separation into a light phase concerned with the generation of a stable assimilatory power, chemically defined as adenosine triphosphate and reduced triphosphopyridine nucleotide, and a dark phase during which the assimilatory power is used for carbon assimilation. A diagrammatic scheme of photosynthesis by chloroplasts, based on these findings, is shown in Fig. 4.

The separation of the light and dark phases of photosynthesis in isolated chloroplasts was aided by the association of each phase with a different portion of the chloroplast. The dark phase of photosynthesis was found to be associated solely with the water-soluble chlorophyll-free extract. The light phase was, as would be expected, localized in the 'grana' fraction which contains the chlorophyll pigments. However, the light phase appears to involve, in addition to the 'grana', some 'stroma' factors. At least one of these, the pyridine nucleotide-reducing factor[26,21,27], must be present if the generation of 'assimilatory power' is to occur in the light.

The CO_2-fixing enzymes are loosely associated with the chlorophyll pigment system in chloroplasts, and in photosynthetic bacteria[46] do not appear to have formed any structural association at all. Why then should carbon assimilation continue to be regarded as an essential part of photosynthesis? Carbon dioxide assimilation by chloroplast enzymes can be studied as a dark process independent of the photosynthetic pigment system. The basic feat of photosynthesis, the conversion of light into useful chemical energy, is accomplished here through the formation of adenosine triphosphate and reduced triphosphopyridine nucleotide (equations 1 and 2). In the living cell these are present in catalytic amounts and hence the trapped light energy is usually, although perhaps not always[21], stored by coupling their formation with carbon assimilation. *In vivo*, the photochemical phase of photosynthesis is therefore tightly bound to carbon assimilation. But in isolated chloroplasts, adenosine triphosphate and reduced triphosphopyridine nucleotides can be made to accumulate in

substrate amounts and their accumulation is a direct measure of the photosynthetic process. Here photosynthesis may be considered as having been completed before carbon assimilation begins. The key problem of photosynthesis, the conversion of light into useful chemical energy, need not, therefore, be enmeshed in the dark enzymatic reactions responsible for the synthesis of carbohydrates.

We are indebted to Dr. F. R. Whatley for the preparation of chloroplasts. We were aided in this investigation by grants from the U.S. Public Health Service and the Office of Naval Research.

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THE JOHN CURTIN SCHOOL OF MEDICAL RESEARCH, AUSTRALIAN NATIONAL UNIVERSITY

ON March 27, Sir Howard Florey, in the presence of the Prime Minister of Australia, the Right Hon. R. G. Menzies, opened the new building of the John Curtin School of Medical Research at the Australian National University in Canberra. The National University was founded in 1946 as a national centre for research and research training, initially in the fields of physical sciences, medical sciences, and the social sciences.

There had long been complaints in Australia that many of the most able scientists left the country because of the greater attractions in universities and research institutions in Great Britain. Such complaints applied more to the medical sciences than to other natural sciences, for which the large and varied laboratories of Commonwealth Scientific and Industrial Research Organization provided first-class facilities, whereas the only medical research institute in Australia with an international reputation was the relatively small Walter and Eliza Hall Institute in Melbourne.

In a report to the Commonwealth Government in 1944, Sir Howard Florey suggested that a national institute for advanced medical sciences should be set up in Australia, and the John Curtin School of Medical Research, established as an integral part of a University devoted to research and research training, is the result of this suggestion. Sir Howard Florey was intimately associated with the development of the School from the time of his report until 1955, and the building he opened on March 27 is a monument to his inspiration and drive. There were no laboratories in Canberra in 1948 when the first professor was appointed, so the departments were started in laboratory space generously lent by several institutions—biochemistry at the Commonwealth Serum Laboratories, Melbourne; medical chemistry at the Wellcome Research Institution in London; microbiology at the Walter and Eliza Hall Institute in Melbourne; experimental pathology in Sir Howard Florey's Laboratories in Oxford and physiology in the University of Otago in New Zealand.

In 1951, temporary laboratories were built in Canberra, and these were occupied between 1952 and 1957, when the departments transferred to the present building (Fig. 1). This is a brick building about 170,000 sq. ft. in floor area. It is built in an H-shape, with four wings for laboratories (which are mainly confined to the upper two floor-levels) and a central spine housing lecture theatre, seminar rooms, offices, tea rooms and library. The lower levels of the building house many of the service departments: store, photography, media kitchens, mechanical plant, etc. In addition, there are two animal houses, each

Fig. 1. The John Curtin School of Medical Research, Australian National University, Canberra

of some 7,000 sq. ft. floor area—one for non-infected and the other for infected animals; an animal-breeding establishment some four miles away, and a large light-engineering workshop.

The laboratory wings have on the south side laboratories 20 ft. deep and on the north side service rooms (hot rooms, cold rooms, etc.) and studies 14 ft. deep. The laboratory layout on each floor-level is adapted to the needs of the particular department, but within the departments it follows a standard plan.

At present there are five departments—biochemistry, experimental pathology, medical chemistry, microbiology and physiology. Prof. A. H. Ennor, head of the Department of Biochemistry, is also dean of the School. His department comprises nine staff and five research students, and is concerned principally with enzymology of phosphorylated guanidines. Prof. F. C. Courtice, well known for his researches on physiology of lymph flow, etc., has just been appointed to the chair of experimental pathology. Prof. Adrien Albert heads a group of seven research workers and two research students in the Department of Medical Chemistry. His work on heterocyclic chemistry is familiar to most British scientists, and he now has greatly increased facilities for this work. Prof. F. Fenner, with seven staff members and eight research students, is investigating various aspects of animal virology, principally with the pox viruses and influenza viruses. The Department of Physiology, headed by Prof. J. C. Eccles, specializes in neurophysiology. Prof. Eccles is at present president of the Australian Academy of Science. His distinguished investigations made by micro-electrode methods are widely known, and he is assisted in this work by seven staff members and four research students.

At present the total research staff is about forty and there are some twenty Ph.D. students; but the John Curtin School of Medical Research is still in the process of growth, both in the sense that several new departments will be developed over the next few years to fill in gaps in the present structure, and in the development of each individual department. The new building just opened by Sir Howard Florey provides excellent facilities in a wide range of the medical sciences and already the School is established as a research institution well known throughout the world.

HIGH ENERGY NUCLEAR PHYSICS

THE annual international conference for 1958 on High-Energy Nuclear Physics, which was held in Geneva during June 30–July 5 under the sponsorship of the International Union of Pure and Applied Physics was the successor to those that have been held annually in Rochester, New York, for the past seven years. Over these years the size and duration of the Conference had increased from a small one-day meeting to a full week of intensive sessions recognized as the most important conference on high-energy physics of the year. It was the general opinion at Rochester in 1957 that the volume of effort and the number of contributions had grown to such an extent that the traditional system whereby each contributor presented the results of his experiments had become unworkable and, short of the undesirable step of limiting the scope of the conference still further, it was evident that some new method of presenting the material had to be tried. This year at the European Centre for Nuclear Research (C.E.R.N.) the conference was divided into ten half-day sessions and all contributions in a particular field were presented to the conference by one person, the rapporteur, whose job it was to introduce the subject and to present and to explain the significance of the results obtained. The talks by the rapporteurs were expected to take up approximately half the session and the other half was left for discussion or for the presentation of special papers which did not fit well into the rapporteur's general scheme. The success of this procedure depends very much on the rapporteur. Contributors were asked to submit their papers to him some four weeks before the plenary sessions. Organizing sessions were arranged on the three days preceding the conference proper to enable participants to meet their rapporteur and if necessary to discuss their contributions with him. As an additional preliminary rapporteurs were asked, prior to the Conference, to provide participants with a reading list which would serve as an introduction to the subjects.

The general opinion at the end of the Conference was that the new method of presentation had been enough of a success for the method to be tried again. It was most successful where the rapporteurs, having been selective in the choice of their material, had leisure to present it in a critical way and not merely as a report of a large number of different experiments.

One of the main disadvantages of the rapporteur system lies in the fact that the reports are very concentrated. Contributors tended to remain anonymous with this method of presentation and it was felt that some advantage would have been gained if mimeographed sheets had been made available before each session, giving the title and authors of the contributions so that further details could the more easily have been sought from them afterwards. Tables of important results would also have proved most valuable. The next International Conference is expected to be held in Moscow in July 1959, where the organizing sessions are to be enlarged to enable contributors to present their results in greater detail to the rapporteur and to others working in the same field.

The first plenary session was devoted to experimental and theoretical reports on nuclear structure. Most of the results reported concerned high-energy electron scattering. Both the charge and magnetic-moment scattering of electrons by protons differs markedly from that obtained on the assumption of a point particle. The results suggest a root-mean-square value for the charge radius equal to that for the magnetic moment, both being equal to 0·8 fermi (1 fermi = 10^{-13} cm.) for the proton, and a similar value for the radius of the neutron magnetic moment distribution, obtained by a comparison of electron–proton and electron–deuteron scattering. The charge core of the neutron appears to be zero at low momentum transfers although a value of 30 per cent of that for the proton at large momentum transfers is not ruled out by the limits of accuracy of the measurements. The different charge radii for the neutron and proton raise the question whether charge symmetry holds or whether the interpretation of the results based on quantum electrodynamics is correct. A word of caution was given by Hofstadter against reading too much into the results until the accuracy is improved, but nevertheless the theoretical interpretation is in a very confused state.

Experiments with muons which can be compared with similar scattering experiments with electrons may be expected to shed more light on the structure of the nucleon during the next few years. The plea for some experimental information on the electromagnetic structure of the pion may have to wait a little longer.

In the two sessions devoted to the nucleon and its interaction with pions, photons, nucleons and antinucleons, some uncertainties which existed at the 1957 Conference in Rochester appear to have been satisfactorily resolved. In 1957 there was evidence that the coupling constant, f^2, obtained from the real part of the forward-scattering amplitude for negative pions via the dispersion relation was very low. However, new measurements of the negative pion–proton scattering cross-section have been made which bring the calculated value of f^2 into line with other determinations. A final value of $f^2 = 0{\cdot}0885 \pm 0{\cdot}002$ was quoted. The experimental and theoretical values for the 'Panofsky ratio' are now also believed to be in good agreement although this was only clarified after considerable discussion. Evidence for the Fermi set of phase shifts is also now well established. An excellent review of the theoretical position was given by Chew. The subject of greatest interest during the past year has been the dispersion relations and the possibility of their violation. However, the theoretical studies that have been made confirmed the belief that the Goldberger relations for forward scattering have a very general basis. Another development was a new type of dispersion relation which allowed a precise determination of the pion coupling constant. A basic question which continues to be obscure is whether it is possible in terms of the pion and nucleon masses and the coupling constant to predict the position of the (3/2, 3/2)-resonance and the small size of the non-charge-exchange S-wave scattering. In the GeV.-region, optical models of the pion-scattering results suggest that the pion–pion interaction is important.

The dispersion relation approach has also been applied to the problem of photon–nucleon scattering and the agreement of theory with experiment is improving. A great deal of discussion centred on the results obtained at Cornell and the California Institute of Technology, where photo-production processes appeared to show a resonance behaviour corresponding to excited states of the nucleon at 300, 600 and 1,000 MeV. The discussion was not conclusive.

There was also much discussion on the possible origin of the spin-orbit interaction introduced into the phenomenological nuclear potential by Gammel and Thaler and by Marshak and Signell last year. The large antinucleon–nucleon total cross-sections have, in fact, now been reasonably explained using a Signell and Marshak type of potential, and although this is again a purely phenomenological approach the feeling has subsided that the large experimental values for the antinucleon–nucleon cross-section would require a major departure from the Yukawa picture.

It is almost traditional now for the discovery of yet another new particle to be announced at the annual conference. This year the anti-Λ^0-particle was reported to have been observed in a two-prong-star event at Berkeley, decaying via a positive pion and antiproton, with a Q value of $35\ ^{+2{\cdot}6}_{-0{\cdot}9}$ MeV. In addition, a cosmic-ray event in a two-level cloud chamber belonging to the Pic du Midi group of the École Polytechnique has provided evidence for the cascade Ξ^0-particle. During the past year, six groups have been doing experiments to establish evidence for the particle of 500 electron masses which was first reported by Alikhanian some years ago. The general conclusion was that its existence was not yet firmly established. More experiments are still being carried out.

In the production of the Λ^0-particle in the pion–nucleon interaction, within the limited accuracy of the measurements, parity is conserved. Existing data are also in agreement with the conservation of isotopic spin. The interaction of K-mesons is explained most reasonably by a pseudo-scalar meson of spin zero. Below 100 MeV. in K^- interactions there is no evidence for anything other than S-waves being important.

One session was devoted to special topics, of which the most interesting related to the origin of the mass of the electron and whether it was entirely electromagnetic or not. An associated problem was the question of the large mass of the muon. It was suggested that a precise measurement of the magnetic moment of the muon would be of great value in order to check whether there was any departure from the value predicted by electromagnetic theory.

Perhaps the most remarkable achievement of the year has been the effort that has gone into the study of parity non-conservation in weak interactions. The two-component neutrino theory is now well estab-

lished. Parity non-conservation appears to be complete and no deviation from invariance under time reversal is observed. There are, however, some points which are not clearly understood. For example, non-conservation of parity is observed in hyperon decay where no neutrino is involved. The magnitude of the $\pi \rightarrow e + \nu$ and $\pi \rightarrow \mu + \nu$ branching ratio provoked much discussion, and it was emphasized that this could prove a very critical test of the universal Fermi interaction. The interaction is now well established as '$V - A$' (vector, axial vector) but the reason why it should be so is still unknown. The beta-decay of the Λ-particle is another puzzle. The present experimental results set the limit for this mode of decay at not more than 1 in 1,000 and they are, in fact, consistent with zero. A new value for the Michel parameter, $\rho = 0{\cdot}735 \pm 0{\cdot}022$, was reported from Berkeley in better agreement with that expected theoretically (0·75). However, the errors quoted are purely statistical and when systematic errors are allowed for, this value may again be changed.

In the case of non-leptonic modes the bulk of the new information concerned the decay modes and the branching ratios for Λ^0 and K^0 and the life-times of Λ^0, K^0 and $\Sigma^{\pm}$. From a study of the angular distribution of the decay with respect to the production direction it appears possible to assign to both the Λ^0 and Σ^- particles a spin of one-half. One new experimental technique, the scintillation chamber, was discussed at a small separate session. It may prove to be a useful new development.

The organizers at C.E.R.N. are to be congratulated on their efficient handling of the conference. The discussions were recorded on tape, typed and in the hands of those concerned for correction within twenty-four hours. The full proceedings of the conference including the talks by the rapporteurs are expected to be available to the participants by October.

G. H. Stafford

NEWS and VIEWS

Entomology and Parasitology at Liverpool : Prof. R. M. Gordon

Prof. R. M. Gordon, who is to retire from the Dutton and Walter Myers chair of entomology and parasitology in the University of Liverpool, acquired an interest in parasitic and arthropod-borne diseases during his army service in Serbia after his qualification at Trinity College, Dublin. Joining the staff of the Liverpool School of Tropical Medicine, he worked in the School's laboratories on the Amazon and in Sierra Leone. He relinquished the directorship of the latter laboratory in 1937 to occupy the chair in entomology in Liverpool; later the chair in parasitology was amalgamated with this. For the past twenty years, in spite of heavy teaching and administrative duties, Prof. Gordon has continued to engage in active research. Primarily a naturalist, not a systematist, he has maintained a 'zoo' of living parasites and their vectors rather than a collection of 'specimens' in his department. Many workers have achieved distinction following the sound training and wide practical experience gained in his department. Early in his career Dr. Gordon, with D. B. Blacklock, first demonstrated immunity to metazoan parasites. The meticulous detail of his work is to be seen in some remarkable micro-cinematograph recordings of the penetration of the mouth-parts of blood-sucking arthropods and their feeding methods. Latterly, the filarial infections have claimed his attention; he largely has originated and directed the helminthiasis research units now working on this problem in West Africa. Prof. Gordon's achievements have entailed much work on committees, which he serves wholeheartedly. The Royal Society of Tropical Medicine and Hygiene conferred its Chalmers Medal on him in 1937; recently it made him its president.

Dr. W. E. Kershaw

Dr. W. E. Kershaw, who is to succeed Prof. R. M. Gordon, joined the staff of the Liverpool School of Tropical Medicine in 1945 as a lecturer in parasitology. He served afloat, and later as a pathologist ashore, with the Royal Navy during the Second World War, and while stationed in Ceylon his contact with the parasitic infections of man determined his future interests. Dr. Kershaw's interests have primarily centred on the helminthiases, and in particular the filariases. His work on the latter has been original and outstanding, and he has travelled widely on field studies in this context. In 1955 he was awarded the Chalmers Medal of the Royal Society of Tropical Medicine particularly for his work in this subject, and his services are in frequent demand at conferences on it in Great Britain and elsewhere. Dr. Kershaw continues an active association with the Navy as a surgeon-commander, an activity which affords opportunity for a more clinical application of his abilities, and which should be of benefit to the Service to which he is proud to belong.

Geology at Southampton : Dr. F. Hodson

Dr. F. Hodson's appointment to the newly created chair of geology at Southampton will give pleasure to geologists at home and abroad, particularly the younger generation. Trained in geology at the University of Reading, Dr. Hodson had the advantage (many forward-seeing geologists would say a necessity) of coming to the subject from two basic sciences. Initially a works chemist and by inclination a zoologist, he was well equipped to profit from university life and ultimately to undertake those researches in Namurian stratigraphy and palæontology for which he has become widely known. His work has shed new light on the Upper Carboniferous rocks of several key areas in western Europe: particularly western Eire, Belgium and the Valenciennes coalfield. In collaboration he has contributed to Jurassic stratigraphy and palæontology. At Reading Dr. Hodson has built up a flourishing Carboniferous research school, devoted mainly to opening up the exciting territory of western Eire. He will take to Southampton not only a tremendous enthusiasm and deep conviction that the 'research outlook' should dominate undergraduate teaching, but also an all-round fitness to foster the several facets of geology and to maintain a sensible balance between competing interests. The University of Southampton may confidently look forward to the

future growth and vigour of its Geology Department, and to whole-hearted participation by its first professor of geology in the progress of this new seat of learning.

Applied Mathematics at Aberystwyth : Prof. T. V. Davies

THOMAS VIVIAN DAVIES, since 1954 reader in mathematics at King's College, London, has been appointed to the chair of applied mathematics at University College, Aberystwyth, in succession to Prof. G. J. Kynch (see *Nature*, **180**, 69 ; 1957). He received his undergraduate training in mathematics under Prof. V. C. Morton and the late Prof. T. Lewis at Aberystwyth, specializing already at that stage in fluid dynamics. During the War he worked with the Ministry of Supply and the Meteorological Office ; since 1946 he has been on the staff of the Department of Mathematics at King's College, London. He went to the United States to carry out meteorological research in 1951, first at the Institute for Advanced Studies at Princeton and later at the Massachusetts Institute of Technology. Mr. Davies has been stimulated principally by geophysical problems : he has developed a new theory of gravity waves of finite amplitude, and has investigated the forced fluid motion and the stability of rotating liquids which are subject to differential heating. More recently, his work has been in the field of magnetohydrodynamics, and in pure mathematics his interests centre on non-linear differential equations. Mr. Davies has served as a member of the Council of the Royal Meteorological Society and of the Meteorological Research Council. His colleagues at King's College, London, have increasingly learned to respect him for his outstanding gifts as a teacher, for his no less inspired success as an originator and director of research in fluid dynamics and, by no means least, for his unassuming friendliness, his quiet efficiency and his other excellent personal qualities. In common with his many other friends, they wish him well in his new sphere of responsibility.

Pure Mathematics at Birmingham : Prof. P. J. Hilton

DR. P. J. HILTON, who has recently been appointed Mason professor of pure mathematics in the University of Birmingham, in succession to Prof. C. A. Rogers (see *Nature*, **181**, 1378 ; 1958), is a graduate of Oxford, where he was a scholar of Balliol College. After taking his degree in 1947 he held lectureships in the Universities of Manchester and Cambridge until he returned as senior lecturer to Manchester in 1955. His research interests have always been in topology, more particularly in homotopy theory, and its recent developments by the methods of homological algebra : he is the author of a Cambridge Mathematical Tract on homotopy. Dr. Hilton has many contacts with European universities, and was appointed by the Royal Society as delegate to the recent mathematical congress in Roumania. He has shown by his talks to radio and other audiences his interest in all sides of the problems of university teaching, and both he and the University of Birmingham are to be congratulated on this appointment.

Foreign Members of the Academy of Sciences of the U.S.S.R.

AT a general session on June 20 the following were elected foreign members of the Academy of Sciences of the U.S.S.R. : *Belgium*, Prof. Z. M. Bacq (biology) ; *Bulgaria*, Prof. G. Nadzhakov (physics and mathematics) ; *Canada*, Prof. E. Steacie (chemistry), Prof. W. Penfield (neurophysiology) ; *China*, Prof. Lee Ssu-Kwang (geology and geography), Prof. Kuo Mo-Zso (history) ; *Korea*, Prof. Pek Nam Yu (history) ; *Czechoslovakia*, Prof. F. Šorm (chemistry) ; *Denmark*, Prof. K. V. Linderstrøm-Lang (biology) ; *France*, Prof. Louis de Broglie (physics), Prof. Louis Néel (physics) ; *German Democratic Republic*, Prof. G. Hertz (physics), Prof. M. Volmer (chemistry) ; *Great Britain*, Prof. J. D. Bernal (physics), Sir Cyril Hinshelwood (chemistry), Prof. C. F. Powell (physics) ; *Hungary*, Prof. I. Rusznyak (biology) ; *India*, Prof. P. C. Mahalanobis (statistics and economics) ; *Italy*, Prof. E. Amaldi (physics), Prof. B. R. Bandinelli (history) ; *Japan*, Prof. S. Kaya (physics) ; *Poland*, Prof. T. Kotarbinski (philosophy) ; *Roumania*, Prof. T. Savulescu (biology) ; *Sweden*, Prof. H. Alfvén (physics), Prof. K. M. B. Siegbahn (physics) ; *Switzerland*, Prof. L. Ruzicka (chemistry) ; *United Arab Republic*, Prof. A. R. Tourky (chemistry), Prof. I. Khalil (literature) ; *United States*, Prof. L. Pauling (chemistry), Dr. D. Bronk (biology) ; *Yugoslavia*, Prof. P. Savić (chemistry).

Royal Society Research Studentships

THE Council of the Royal Society has awarded Mr. and Mrs. John Jaffé Donation Studentships in original scientific research from October 1 to Dr. E. A. Magnusson to continue his study of the modification of atomic orbitals in bond formation in the Department of Chemistry, University College, London, and to Dr. Jennifer Wildy to work on the biosynthesis of the protein and hæm components of hæmoglobin in the Department of Chemical Pathology, University College Hospital Medical School.

Nutrition Society of Canada

A MEETING of persons interested in nutrition research was held in Ottawa on October 7, 1957, to discuss the formation of a nutrition society. A provisional committee was appointed to prepare a list of founding members and to draft a constitution. On June 8 a formal meeting took place in Queen's University, Kingston, Ontario. A membership of ninety was accepted, a constitution adopted, and the society was named the Nutrition Society of Canada. Membership is restricted to persons concerned with the scientific aspects of nutrition. Officers of the Society are : *President*, E. W. McHenry (Toronto) ; *Vice-President*, E. W. Crampton (Ste. Anne de Bellevue) ; *Secretary*, George H. Beaton (Toronto) ; *Treasurer*, J. A. Campbell (Ottawa) ; *Members of Council*, D. H. Copp (Vancouver), W. W. Hawkins (Halifax), L. B. Pett (Ottawa). The Society intends to hold annual meetings.

Aerial Geophysical Survey of Cornwall

IN a written answer to a question on July 15 regarding the aerial geophysical survey of south-west Cornwall made last year for the Atomic Energy Authority, Mr. H. Nicholls, Parliamentary Secretary to the Ministry of Works, as representing the Lord President of the Council, said that the Department of Scientific and Industrial Research has recently published a brief description of this air-borne survey made by the radiometric method. A scientific appraisal of the work will be presented in a paper at the Second International Conference on the Peaceful Uses of Atomic Energy to be held at Geneva early in September and will be published in the Proceedings

of the Conference. Ground investigations are continuing in Cornwall and it will be some time before all data recorded from the air have been assessed.

Design in Industry

Many interesting suggestions concerning the education and training of designers for the furniture, pottery, printing and textile industries are contained in "The Training of Designers for Industry" (pp. vii+50. Federation of British Industries, 21 Tothill Street, London, S.W.1, 1957. 3*s*. 6*d*.). This is the report of a one-day conference between industrialists and educationists, organized under the auspices of the Federation of British Industries and held in London on September 24, 1957. The booklet includes the opening address by Sir Edward Boyle, Parliamentary Secretary to the Ministry of Education, and reports by the chairmen of the five discussion groups on important points made in the course of the conference, together with a summing-up by Sir Ernest Goodale, chairman of the Federation's Industrial Art Committee. It also includes the memoranda circulated before the conference as bases for the group discussions.

National Science Foundation Programme for Atmospheric Sciences

An Atmospheric Sciences Programme is being established by the U.S. National Science Foundation as a result of recommendations by the President's Committee on Weather Control and the Committee on Meteorology of the National Academy of Sciences —National Research Council. The new programme will deal with meteorology, including not only the more conventional type of meteorological research, but also energy transfer processes between earth, sea and air; turbulent flow of gaseous fluids; heat exchange processes; upper atmosphere studies (that is, above the level of conventional meteorological work); atmospheric chemistry; and general circulation problems of the atmosphere and oceans. Attention will also be given to the field of cloud physics, especially the physics of precipitation, where much basic research must be pursued before the possibilities of controlling or modifying weather can be evaluated. The programme director will be Dr. Earl G. Droessler, who has wide experience in administration and co-ordination of military scientific research and development, and in research in meteorology and glaciology.

Agricultural Meteorology in India

A special issue of the *Indian Journal of Meteorology and Geophysics* was published in December 1957 in honour of the silver jubilee of the Agricultural Meteorology Division of the India Meteorology Department. The importance of the scientific study of the relations between crops and weather has long been recognized, notably early in this century in Britain by Sir Napier Shaw, and the International Meteorological Organization formed its Commission for Agricultural Meteorology in 1913. It is, however, only in relatively recent years that stations specifically equipped and staffed by meteorological physicists have been set up to make detailed micrometeorological and related observations. India, under Sir Char'es Normand's tenure of the post of Director-General of Observatories, was one of the first countries to establish such a unit. The Division was formed at Poona in 1932 and placed under Dr. L. A. Ramdas, who remained in charge until 1953.

The Central Agricultural Meteorological Observatory is on the farm of the Agricultural College at Poona. It is equipped with instruments for observing the micro-structure of the atmosphere up to 35 ft. in the free air and within crops, and also radiation, evaporation, soil properties and plant temperatures. The Division also controls less detailed meteorological work at some forty other experimental farms in India, and maintains weekly charts of the relevant weather elements and of the progress of crops all over India. The major work now in progress is concerned with the water requirements of plants, the relation between weather and the incidence of disease and pests and the preparation of crop–weather calendars for the guidance of regional meteorological centres in the preparation of the weather forecasts for the farmers' weather bulletins. It was at this Division that the observation was first made that under clear sky at night the air just above ground is often colder at a height of 5–15 cm. than at the ground itself. This observation, scarcely credited for a time, has been repeated at several places elsewhere with other types of apparatus but is still not fully explained.

University College, London: Report for 1956–57

The annual report of University College, London, for 1956–57 (pp. 89. London: University College, 1958) includes the report of the chairman of the College Committee and the provost, together with those of the Students' Union, the Bartlett School of Agriculture and the Slade School of Fine Art, and lists of publications of members of academic departments. Of the 3,574 students (including 795 part-time) 755 were postgraduate (239 part-time). Some 589 undergraduates and 318 postgraduates were in the faculty of science and 206 undergraduates and 66 postgraduates in engineering. The year was the last of the old quinquennium, which closed with a deficit of £2,455, and the report, commenting on the absence of general funds for research, records the severe disappointment with the grant from the University Grants Committee for the new quinquennium: that of £1,165,000 for 1957–58 will permit no academic expansion and will necessitate a substantial cut in maintenance. Capital expenditure of £280,000 was concentrated on the new Biological Sciences Block, but the planning of the first stage, to cost £500,000, of the new Engineering Building is well advanced. In the Department of Chemistry investigations of the mechanisms of reactions in solution have recently been correlated with studies of reactions in the gas phase, and some main lines of investigation have been greatly facilitated by the installation of a nuclear magnetic resonance apparatus through the generosity of the Wellcome Trust. In the Department of Physics assembly of the microtron has proceeded satisfactorily (see *Nature*, June 21, p. 1726), and the new high-pressure cloud chamber has been assembled and tested.

Arthur D. Little Research Institute

The first annual report of the Arthur D. Little Research Institute (Inveresk, Midlothian), inaugurated on March 22, 1957, records that on December 31 the Institute's staff totalled twenty-two, of whom twelve were qualified scientists. The three projects under investigation at that date embraced a general study of linear polymers of spatially regular structures, including the mechanism and kinetics of formation of such polymers and their physical properties; a

study of sucrose, starting with the sodium sucrates and their condensates with chloro compounds; and a corrosion project including an investigation of the effect of the structure of organic additives, with particular emphasis on physical and chemical inhibition mechanisms around the neutrality point. Five papers published during the year are listed, as well as the titles of six others submitted for publication.

Climatic Tables

THE Meteorological Office receives a very large number of inquiries for climatic data for places in all parts of the world from industrial firms and others. Many of these inquiries relate to temperature, humidity and precipitation and it has been the practice to prepare and sell mimeographed tables of these elements to inquirers. The data most required are now being published (Air Ministry: Meteorological Office. Tables of Temperature, Relative Humidity and Precipitation for the World. London: H.M. Stationery Office, 1958) in six parts as follows: (1) North America, Greenland and the North Pacific Ocean; (2) Central and South America, the West Indies and Bermuda (to be published shortly); (3) Europe and the Atlantic Ocean north of 35° N. (to be published shortly); (4) Africa, the Atlantic Ocean south of 35° N., and the Indian Ocean; (5) Asia; (6) Australia and the South Pacific, Antarctica. Each part gives monthly values of the following information for a carefully selected and representative set of several hundred observing stations: temperature: average daily maximum and minimum, average highest and average lowest in each month, absolute maxima and minima; relative humidity: average values, varying times but selected as far as possible to give night and midday values; precipitation: average monthly fall, maximum in 24 hr., average number of days of 0·01 in. or more. Each part has a map showing the stations, an index, and bibliography of sources, and the latitude, longitude and height of each station is given in the tables. Great care has been taken in collaboration with the British Government's Permanent Committee on Geographical Names to give place-names under all the forms by which each is likely to be known, a matter of no small difficulty for places in the Far East and U.S.S.R. All six volumes are also being made available bound into one book.

The Absorption Spectrum of Water Vapour

IN his paper, "Das Spektrum des Wasserdampfes" (*Ber. Deutsch. Wetterdienstes*, Nr. 44, 6; 1958), W. Regula gives a valuable summary of the theory of, and experimental information on, the absorption spectrum of water vapour over the wave-length range 1·35 cm. to 300 A. The positions of the absorption bands are given in tables under the type of process responsible. The intensities are indicated qualitatively (strong, medium, weak) in most instances. The paper may be useful to physicists as well as meteorologists.

Spectrum of the Night Sky

IN a paper on the altitude of atmospheric layers emitting the lines [O I] 5577 A., [O I] 6300 A. and [Na I] 5892 A. (*Pub. de l'Observ. de Haute-Provence*, 3, No. 36; 1957), Jean Dufay and Tcheng Mao-Lin have re-examined all the observations of the bright lines in the night-sky spectrum. Following the method described by Barbier, corrections for extinction and for scattered light have been made. Taking into account only the molecular scattering and the absorption by atmospheric ozone, the following equivalent heights are obtained: λ, 5577 A., z, 195 km.; λ, 5892 A., z, 200 (or 230) km.; λ, 6300 A., z, 280 km. If, however, a thin layer of haze is present in the lower atmosphere, producing at the zenith the additional optical density $D_0(v) = 0{\cdot}0050$, these heights may be reduced to 170, 170 (or 200) and 250 km., respectively. The uncertainty arising from a selective absorption by water vapour and by oxygen molecules, chiefly from the emission of the OH band, is also discussed.

Cricket Bat Willow

Salix alba var. *caerulea* is as a timber tree unique in Britain, in that the care lavished on it during (and after) its lifetime is reminiscent more of the practices of horticulture than of forestry. This is the result of the high value of its timber when well grown. Current methods of producing timber of the best quality are fully described in "Cultivation of the Cricket Bat Willow" (Forestry Commission. Bulletin No. 17. Pp. vi+34+33 plates. London: H.M. Stationery Office, 1958. 5*s.* net). Rooted or unrooted 'sets' (cuttings) are planted widely (at least 30 ft. apart), lateral branches are removed early and buds appearing on the main stem are rubbed out before they become woody, to a height of 8 ft. Thus a mature stem 8 ft. long and free of knots is produced, but even so, only the lower part of the trunk may give timber suitable for cricket bats of the highest quality. Rapid growth gives the desired sapwood (heart wood is not used in bat making) with annual rings up to 1 in. in width, and this with a straight grain combined with toughness and ability to withstand compression are all characters looked for in the timber by the bat maker. It is now known that male as well as female trees may combine all these desirable qualities in their wood, but they will be lacking unless the site is carefully chosen, insect pests controlled, and protection from grazing animals afforded, and even then 'stain' may develop in the timber, or water-mark disease (due to *Bacterium salicis* Day) affect the trees, rendering them virtually useless.

Control of Aquatic Weeds

PROGRESS in the control of weeds on agricultural land has not been paralleled by the evolution of reliable methods for the control of aquatic weeds. Present-day practices and the results of recent research in this field are summarized by Aylwin P. Chancellor in "The Control of Aquatic Weeds and Algae" (pp. 20. London: H.M. Stationery Office, 1958. 2*s.* 6*d.* net). Mechanical methods of removing weeds from ponds and lakes are often preferable to chemical means, but for emergent weeds in still or running water the use of growth substances (particularly sodium 2 : 2-dichloropropionate) offers great promise. Sodium arsenite can be used to control submerged weeds in still water and is effective at concentrations that are harmless to fish. Submerged weeds in running water cannot be satisfactorily controlled, while chlorine and copper sulphate, both effective in controlling algae, have the disadvantage of extremely high toxicity to fish. Added to this is the fact that if a heavy growth of algae is killed off, the products of decay and the great reduction in the oxygen content of the water may be undesirable. Treatment in spring or early summer may kill the

pioneers of the algal flush of growth so that control without any secondary ill-effect is secured.

American experiments indicate that the concentration of copper sulphate necessary to control some algae (for example, 5·0–10·0 p.p.m. for *Scenedesmus*) may greatly exceed the limits tolerated by fish. Trout, for example, in River Itchin water containing 1 p.p.m. of copper sulphate were killed within 24 hr. Chlorine has similar disadvantages, but rosin amine compounds and 2 : 3-dichloronaphthoquinone both have promise as algicides.

Zoological Nomenclature

The International Commission on Zoological Nomenclature gives notice that, as from December 6, it will start voting on the following cases involving the possible use of its plenary powers for the purpose specified against each entry. Full details of these cases were published on June 6 in the *Bulletin of Zoological Nomenclature* (16, Part 2) : *Mysis* Latreille [1802–1803], designation of type species for, and validation of neotype for species (*Cancer oculatus* Fabricius, 1780) so designated (Cl. Crustacea, Order Mysidacea) ; (2) *Dactylioceras* Hyatt, 1867, designation of type species for (Cl. Cephalopoda, Order Ammonoidea : Jurassic) ; (3) *gemmascens* Esper [1794] (*Madrepora*), validation of (Cl. Hydrozoa, Order Stylasterina). Comments should be sent as soon as possible in duplicate to R. V. Melville, assistant secretary to the Commission, 28 Park Village East, Regent's Park, London, N.W.1.

A Kerr Cell Electro-Optical Shutter

An exposure time of 0·01 μsec. is claimed for the Kerr cell electro-optical shutter and improved pulse-generator circuit devised by Avco Manufacturing Corporation's Research and Advanced Development Division (Lawrence, Massachusetts). The cell is of 2 in. square cross-section, and the electric field needed to produce phase rotation of the electromagnetic vector as it passes through a cell filled with nitrobenzene is 10–15 kV./cm., so that for a 5-cm. aperture the pulse generator must deliver a pulse of 50–75 kV. to the Kerr cell plates. The generator consists of a coaxial cable and a spark gap, and the cell is connected directly across the load resistor on the transmission line. Exposure time can be varied accurately from 0·01 to 0·1 μsec. by changing the length of the transmission line. The form of the exposure characteristic is approximately square-wave. The selective absorption polarizing material used for the polarizer and analyser on the cell does not provide a completely opaque shutter in the 'off' position, but a transmission ratio of about 20,000 to 1 is obtained with ordinary stock material. The angle of incident light must be limited to 10 deg. or less from the normal, providing a limiting aperture of about $f/2·5$ and an effective aperture of about $f/10$ in operation of the shutter.

Geochemistry

Certain aspects of migration of the chemical elements in the Earth's crust during geological times are discussed by A. A. Saukov (*Priroda*, 2, 10 ; 1958). While the majority of migration processes may be considered to be of a non-directional character, certain processes may give rise to directional types of migration. Thus, the gradual diminution of the quantities of radioactive elements in the Earth and a consequent diminution of the thermal energy of radioactive source may have affected the intensity of metamorphism and magmatism during the geological history. Also, one may consider that the emergence and development of the biosphere has greatly affected the nature and the intensity of migration of the elements, which not only determine the 'directed' accumulation of such organogenic deposits as, for example, coal, bitumen and limestone, but also lead to the accumulation of free oxygen in the atmosphere. This, in its turn, may have affected the behaviour of iron compounds present in the hydrosphere, by a widespread precipitation of the oxidized ferric forms, so prevalent in the widespread iron ore deposits formed in the Pre-Cambrian metamorphic rocks.

National Science Foundation Grants for Science

The National Science Foundation awarded 246 grants totalling 4,720,545 dollars during the quarter ending March 31, 1958, for the support of basic research in the sciences, for conferences in support of science, for exchange of scientific information, for short-term research by medical students, and for training of science teachers. This is the third group of awards to be made during the current fiscal year. During the first two quarters, awards totalled almost 20·5 million dollars. The research fields included are astronomy, chemistry, biology, physics, earth sciences, engineering sciences, mathematical sciences and social sciences.

Society for Applied Bacteriology

At the recent annual meeting and summer conference of the Society for Applied Bacteriology, held in Bristol, the following officers of the Society were elected : *President*, Mr. D. A. McKenzie ; *Hon. Secretary*, Mr. G. Sykes (Boots Pure Drug Co., Ltd., Microbiology Division, Standards Department, Nottingham) ; *Hon. Treasurer*, Mr. G. Elis Jones ; *Editor-in-Chief*, Dr. S. E. Jacobs ; *Editor*, Dr. C. A. E. Briggs ; *Hon. Publications Manager*, Mr. A. H. Walters ; *Hon. Advertising Manager*, Mr. E. J. Mann ; *Committee*, Dr. Eve Billing, Mr. N. J. Butler, Prof. E. L. Crossley, Dr. J. G. Davis, Dr. N. R. Knowles, Dr. Jane Meiklejohn, Mr. C. A. Scarlett, and Dr. M. Woodbine.

Darwinism and the Study of Society

To mark the centenary of "The Origin of Species", a conference, organized by the Social Sciences Research Centre of the University of Edinburgh, will be held in Adam House, Edinburgh, during April 8–10, 1959. The proceedings will be divided into six sessions, as follows : (1) "Darwin's Place in the History of Thought", Prof. B. Willey (Cambridge), "The Intellectual Background during Darwin's Student Years in Edinburgh", Mr. G. A. Shepperson (Edinburgh) ; (2) "Darwinism and Human Society in Retrospect", Prof. Lancelot Hogben (Birmingham), "Natural and Social Selection", Dr. W. Stark (Manchester) ; (3) "Genetic Determinants of Human Behaviour", Prof. C. H. Waddington (Edinburgh) ; (4) "Social Evolution", Prof. Morris Ginsberg (London) ; (5) "Communication in Animal and Human Societies", Mr. S. A. Barnett (Glasgow) ; (6) an appraisal of the conference by Dr. J. Bronowski (director of the Coal Research Establishment) and Prof. Asa Briggs (Leeds). Further particulars may be obtained from Dr. M. P. Banton, 39 George Square, Edinburgh 8. Limited accommodation for visitors will be available in one of the University halls of residence ; early application is advised.

International Symposium on Combustion

THE seventh International Symposium of the Combustion Institute will be held during August 28–September 3, under the auspices of the British Section of the Institute and the Institute of Fuel, 18 Devonshire Street, London, W.1. It is the first occasion on which the Symposium has been held outside the United States. Participants are attending from more than fifteen different countries. Dr. Bernard Lewis, president of the Combustion Institute, Dr. von Kármán, and many others will attend from the United States, and Academician N. N. Semenov will be among those from the U.S.S.R. Participants are expected to register at the Institute of Fuel on August 27. There will be a reception for those coming from overseas on that evening, given by Her Majesty's Government at Lancaster House. The opening meeting will be held on August 28 at the Royal Institution, Albemarle Street, at 10 a.m. There will also be a visit to the Laboratories of Combustion Research at the Imperial College of Science and Technology and a dinner at the Guildhall that evening, at which Lord Brabazon will be the chief guest. The rest of the proceedings will be held in Oxford, during August 29–September 3, when about a hundred papers (preprinted and circulated) will be discussed in fourteen separate sessions, only four of which will overlap.

University News : London

THE following appointments in the University of London have recently been announced: Dr. D. Gabor, Mullard reader in electronics at the Imperial College of Science and Technology, to the University chair of applied electron physics at that College; Prof. L. J. Lewis, B.Sc. (Wales), former director of the University College of Ghana Institute of Education, to the University chair of education, with special reference to education in tropical areas, at the Institute of Education; Dr. J. Sutton, reader in geology, to the University chair of geology, and Dr. R. D'A. Hoyle, senior lecturer in mechanical engineering, to the University readership in mechanical engineering, both at the Imperial College of Science and Technology; Dr. W. J. H. Butterfield, to the University chair of experimental medicine at Guy's Hospital Medical School.

The title of professor in the University has been conferred on the following in respect of their posts at the Colleges and Schools indicated: Dr. R. S. Stacey (pharmacology and therapeutics in St. Thomas's Hospital Medical School); Dr. Eleanor J. Zaimis (pharmacology in the Royal Free Hospital School of Medicine).

The title of reader in the University has been conferred on the following: Mrs. J. E. Floud (sociology of education in the Institute of Education); Dr. R. J. Harrison-Church (geography in the London School of Economics and Political Science); Mr. O. R. McGregor (social institutions in Bedford College).

The title of professor emeritus has been conferred on the following, on their retirement from chairs at the Colleges and Schools indicated: Prof. W. N. Bailey (mathematics at Bedford College); Prof. K. J. Franklin (physiology at St. Bartholomew's Hospital Medical College); Prof. F. M. Haines (botany at Queen Mary College); Prof. L. Dudley Stamp (social geography at the London School of Economics and Political Science).

Dr. A. R. Fairbairn has been appointed to the General Motors Corporation of Detroit postdoctoral fellowship in flame spectroscopy, tenable at the Imperial College of Science and Technology.

Swansea

THE following appointments have recently been made in the University College of Swansea: Dr. S. K. Zaremba, to be lecturer in the Department of Pure Mathematics; Dr. E. G. Brown, to be lecturer in the Department of Botany; Mr. J. D. Davies, to be lecturer in the Department of Engineering.

Announcements

THE British Society of Rheology is organizing a conference on "Rheology of Road Materials" to be held at the Road Research Laboratories, Harmondsworth, on October 24. Further information can be obtained from the Honorary Secretary, 52 Tavistock Road, Edgware, Middlesex.

THE second International Congress of Speleology will be held at Bari, Lecce and Salerno in Italy during October 5–12. Further information can be obtained from the secretary-general of the Congress, Prof. Franco Anelli, Castellana-Grotte, Bari, Italy.

THE International Association of Allergology is holding the third International Congress of Allergology in Paris at the New Medical School during October 19–26. Further information can be obtained from the secretary, B. N. Halpern, 197 Boulevard St. Germain, Paris, 7e.

THE next standard course at the Harwell Reactor School on which places are available starts on November 10, and ends on March 6, 1959. The fee for the course is £250 exclusive of accommodation. Applications will be considered from overseas as well as the United Kingdom. Forms and further information can be obtained from the Principal, Reactor School, Atomic Energy Research Establishment, Harwell, Didcot, Berkshire.

THE Foundations' Fund for Research in Psychiatry announces that October 15 is the latest date for the submission of completed applications for research fellowships in psychiatry, psychology, sociology, neurophysiology, and other sciences relevant to mental health. The latest date for applications for research grants-in-aid is December 10. Further details can be obtained from the Foundations' Fund for Research in Psychiatry, 251 Edwards Street, New Haven 11, Connecticut.

THE Research Fund of the Chemical Society provides grants for the assistance of research in all branches of chemistry. About £700 per annum is available for this purpose. Applications for grants will be considered in November next and should be submitted on the appropriate form not later than November 14. Applications from Fellows will receive prior consideration. Further information can be obtained from the General Secretary, The Chemical Society, Burlington House, Piccadilly, London, W.1.

ERRATUM. Mr. M. J. Lyons has written referring to his communication entitled "Presence of 1,2,3,4-Dibenzopyrene in Cigarette Smoke" in *Nature*, of July 19, p. 178, stating that the first sentence of paragraph 4 should read: "Small quantities of 1,2,3,4-dibenzopyrene have been detected in the exhaust products from petrol and Diesel engines".

PROGRESS IN CANCER RESEARCH

THE Seventh International Cancer Congress, organized by the International Union against Cancer, was held in London during July 6–12 under the presidency of Sir Stanford Cade. A meeting involving about 600 papers and 2,500 members is not easy to survey: as was to be expected, nothing dramatic emerged and in these circumstances it is almost impossible to judge where the most significant advances are in fact being made. Specialists in the many disciplines embraced by cancer research would all have differing ideas on this, and a short review of the proceedings must therefore be a biased one.

Hormones

O. Mülhbock (Holland) expressed the view that cancer induced by hormones is always the result of super-normal production of a growth-stimulating hormone and that hormonal deficiency never gives rise to neoplasia. Mülhbock and his co-workers have shown that breast carcinoma can be induced in mice free from the milk factor by the repeated implantation of pituitary glands from mice of the same strain. A. Lipschutz (Chile) described the occurrence of an ovarian neoplasm (luteoma) following sub-total castration. This is possibly another instance of pituitary over-stimulation. R. E. Kavetsky and his colleagues (U.S.S.R.) provided evidence that disturbance of the rhythm of activity of the pituitary gonadotropic and mammatropic hormones was a feature of high-cancer strains of mice. Another example is that described by J. Bielschowsky (New Zealand) in the case of thyroid tumours, the genesis of which is dependent on continuous over-stimulation by the pituitary thyrotropic hormone. The tumour itself may continue to be dependent on the same hormonal stimulation. This property has been utilized in treatment in man, since by administering a goitrogen the tumour can be induced to secrete thyroxin and thus become vulnerable to radioactive iodine.

One has the general impression that the relation between hormonal stimulation and cancer is being clarified rapidly and its role in the genesis of human tumours, particular of the breast, may prove important. The mechanism is still little understood, but the knowledge that certain tumours of tissues responsive to sex-hormones may still be dependent on such hormones has resulted in a significant therapeutic advance. C. Huggins (United States), who has notable achievements in this field to his credit, reviewed the treatment of cancer of the breast by surgical removal of the ovaries and the adrenal and pituitary glands. Both he and H. Shay (United States) described useful and rapid methods of inducing cancer in the breast of rats by intensive but limited oral treatment with methylcholanthrene.

Metabolism of Carcinogens

The fate of injected chemical carcinogens with its corollary, the mechanism of carcinogenesis, was a dominant topic. I. Berenblum (Israel) reviewed this subject and suggested that with the polycyclic hydrocarbons there is still no firm evidence on whether the carcinogen itself or a metabolite is the decisive factor. On the other hand, C. Heidelberger (United States) argued that carcinogenic activity is correlated directly with specific protein-binding as a first step leading eventually to the deletion of the essential enzymes regulating cell-growth. He gave evidence that the binding is in the *K* region first described by the Pullmans. A. Pullman (France) described his electronic theory and urged greater co-operation on the biological side which will be necessary to test its validity. The theory demands protein-binding with the carcinogen and not with a metabolite.

H. R. Gutmann (United States) showed that an *ortho*-hydroxyamine derivative from 2-acetylaminofluorene is capable of protein-binding in simple biochemical systems. Specific protein-binding as the primary process in carcinogenesis is an exceedingly important concept and, though not mentioned extensively at the Congress, its implications in the immunological approach to cancer were stressed by H. N. Green (Great Britain) and others.

The metabolism of the carcinogenic aromatic amines is largely linked up with studies on bladder cancer. G. M. Bonser (Great Britain) described the pioneer work by which she and her colleagues had shown that 2-naphthylamine is carcinogenic to the bladder of dog and man by virtue of its conversion to 2-amino-*l*-naphthol. The evidence that *ortho*-hydroxyamines are of importance in amine carcinogenesis in general was amplified by D. B. Clayson (Great Britain) and L. Bradshaw (Great Britain) in relation to the metabolic fate of benzidine and 4-aminodiphenyl.

E. Boyland (Great Britain) suggested that carcinogenic metabolites may be liberated in the bladder by the action on the *ortho*-amino phenol conjugates (formed in the liver) of the enzymes glucuronidase and phosphatase. He described carcinogenic *ortho*-aminophenols (for example, 3-hydroxyanthranilic acid) which are products of tryptophan metabolism and so may be endogenous carcinogens. Since urinary β-glucuronidase is inhibited by oral administration of 1 : 4-glucosaccharolactone, the possibility of preventing bladder cancer arises.

Ionizing Radiations

Interest in ionizing radiations was mainly focused on the carcinogenic hazard in man and the induction of tumours in mice. R. Doll (Great Britain) described the definite but low incidence of leukæmias induced by X-rays in man and the evidence supporting somatic mutation as the cause. A. M. Brues (United States) opposed this view, because the evidence also suggests that the risk of carcinogenesis increases disproportionately to the dosage.

One of the many interesting ways of inducing cancer by irradiation was described by P. Furth (United States) who, by irradiating the pituitary gland, produced tumours which were functional and thus induced tumours in other conditioned target organs. L. W. Law (United States) described malignant lymphomas in mice given homologous or semi-isologous bone marrow as a protection against lethal irradiation. H. S. Kaplan (United States) argued that carcinogenic agents may act indirectly since thymic leukæmias occur in the unirradiated thymus grafted into thymectomized mice subjected to prior irradiation. N. Petrov (U.S.S.R.) and his co-workers described the production of tumours in the bones of apes by the local action of radioactive minerals, an effect not obtained with carcinogenic hydrocarbons.

Viruses

Tumour viruses were widely discussed, but the outstanding interest was in the leukæmia viruses of mice. L. Gross (United States) discussed his work on the induction of leukæmia and parotid tumours with cell-free extracts of leukæmia tissues given to new-born mice. C. Friend (United States) described similar extracts rapidly inducing leukæmia in adult mice, while T. Latarjet (France) dealt with cell-free extracts —and deoxyribonucleic and ribonucleic acids derived from them—accelerating the onset of leukæmia and inducing the appearance of other tumours. These and other important contributions have great theoretical interest. Their relation to human leukæmias is doubtful, and indeed Sir Macfarlane Burnet rather disturbed the cancer virus experts by his categorical declaration on epidemiological grounds that viruses played no part in the etiology of solid tumours in man.

Immunology and Immunogenetics

There were signs of a mounting interest in the field of immunology and immunogenetics not only in the number of directly relevant papers submitted but also in the references to immunological approaches in many others. H. N. Green (Great Britain) described his immunological theory, which ascribes the neoplastic state to absence of tissue-specific immunological identity in the cell. Evidence was presented that a specific antigenic complex is formed by carcinogen binding probably with a lipo-protein complex which, possibly as a result of an immune reaction, results in the emergence of a strain of cells lacking such a complex. E. Weiler (United States) has previously found a loss of tissue-specific antigens in chemically induced tumours of the liver and kidney and, by ingenious isotopic and immune techniques, has now demonstrated their loss in the second generation of normal kidney epithelium tissue culture. The failure to induce chemical carcinogenesis, contrasted with the occurrence of malignant transformation in tissue culture, was one of the many facts presented originally in support of Green's theory. C. A. Zilber (U.S.S.R.), as well as G. P. Cunningham and his co-workers (Great Britain), indicated that an antigenic complex is formed in chemical carcinogenesis of the liver. Zilber found that this disappears, to be replaced in the tumour by a specific antigen with no carcinogen specificity. Tumour antigens are found in human and virus tumours. Antigenic change in tumours is both quantitative and qualitative.

Sir Macfarlane Burnet, in a broad survey of the biological nature of cancer, concluded that it can best be explained on a basis of somatic mutation and clone selection. The problem is to find whether these mutations are due to random action of many kinds of stimuli, deviation of some process of cellular differentiation or enforced and directed mutation by the action of specific substances. The auto-immune state is not excluded as a cause, but more experimental support is needed. G. Klein (Sweden) suggested that the evolution of the neoplastic cell towards greater autonomy is due to intercellular variation followed by selection. L. Sachs (Israel) demonstrated that though greater freedom of transplantability may involve loss of agglutinogens it always implies greater antigenicity in general, a finding which is by no means opposed to an immunological theory of loss of cytoplasmic specific antigens.

Immunological ideas are being increasingly used in experimental therapy, for example, in tagging radioiodine on to tissue-specific antibody globulin (by I. L. Spar and his co-workers in the United States).

Space does not allow of discussion of many important subjects. Naturally, the relation between smoking and cancer was a prominent topic, and half the Congress was devoted to clinical papers. These topics and the important subject of the control of cancer are of great importance, but they will be covered fully in the medical press. Chemotherapy, however, must be mentioned here, as it occupied an important part of the proceedings. Many new synthetic compounds were described, the present emphasis being away from the radiomimetic and towards the antimetabolic compounds. Nevertheless a large amount of work still stems from the original work of A. Haddow and his colleagues on therapy with alkylating agents. Moreover, the great number of papers on nucleic acid metabolism and carcinogenesis reported at the Congress were derived largely from the original studies on the mechanism of action of such agents.

Even a long review could not be fair to every significant contribution. It is indeed very possible that among the hundreds not mentioned specifically some may have more potential importance than any cited here. For example, the work of K. Setälä and his co-workers (Finland) on the cancer-promoting activities of 'Tween 60' or of the purely physical induction of cancer by plastic films by E. T. Oppenheimer (United States) may fall within this category. The cancer scene still covers a broad canvas and the vitally important detail may not yet have been emphasized.

H. N. Green

BRITISH RAYON RESEARCH ASSOCIATION

OPEN DAYS

THE British Rayon Research Association held the third of its annual open days during May 7–9. The total attendance was 650–700, some 300 attending on the second day. A new technological building has been built and this houses the wool processing machinery, the work on vibration problems on spinning frames and the fluid-bed work. All the work of the Association was shown with the exception of that on fluid beds, which, as it has been moved twice in the past twelve months, was not in a suitable condition for demonstration. In order to present the fundamental work in a form which showed its relevance to problems in the textile industry, two short lectures on the work of the chemistry and physics groups were given by the senior chemist and senior physicist immediately after lunch on each day. These were well attended and well received.

Because of the disorganization caused to technological work by the vacation of the Barton Dock Road premises and the subsequent upheaval in the

Association when the additional technological building was brought into use, the different sections have been reduced in their activities for periods varying from two to three weeks to two to three months. This interruption to the work has been utilized to reconsider the machines which are required for future work and also to review the research programme. As a consequence the amount of new development which could be demonstrated was rather less than in previous years.

On the chemistry side, the work on the alkaline degradation of cellulose is being reviewed and the general picture of the mechanism of degradation has been modified to account for the presence of the large number of acidic products[1]. The study of the kinetics of the oxidation of model compounds, preparatory to a study of the oxidation of cellulose, has been continued. Even in the case of ethyl alcohol the mechanisms originally proposed have been shown not to be sufficient to account for all the kinetic results. Thus it is necessary to postulate a unimolecular decomposition of the peroxy-radical which competes with a bimolecular process; for example, in the case of ethyl alcohol the essential reactions appear to be:

$$RO_2\cdot \rightarrow CH_3CHO + HO_2\cdot$$
$$RO_2\cdot + RO_2\cdot \rightarrow 2\,CH_3CO_2H + H_2O_2$$

In the early work, anthraquinone sulphonate (Q) was used as the sensitizer, thus

$$Q \xrightarrow{h\nu} Q^*$$
$$Q^* + RH \rightarrow QH\cdot + R\cdot$$
$$R\cdot + O_2 \rightarrow RO_2\cdot$$

Recently hydroxyl radicals, produced by the action of ultra-violet light on hydrogen peroxide, have been used as the hydrogen atom abstractors, and it has been shown that their action is much less specific than that of excited anthraquinones. Whereas for anthraquinones the results can be accounted for by assuming abstraction of an α-hydrogen atom, it appears necessary to assume that hydroxyl radicals can abstract hydrogen atoms at other positions.

A subject of great interest to the Association is that of the fine structure in cellulosic materials. Work is still proceeding on ways of determining whether the microfibrillar structures observed could be complete or partial artefacts. During the past year or so, two approaches to the problem of determining the mechanism of formation of structure in solution-spun polymers have been started. The first method is to follow the volume changes during gelation of cellulose acetate in different solvents. The second one is to study the light-scattering of the solution.

A possible complication in interpreting the results of stress-birefringence measurements is that, in general, birefringence can be caused not only by the orientation of anisotropic polymer units but also by anisotropy in the spatial configuration of these units. Experimental departures from the simple orientation theory in solvent-swollen polymer systems have been classified under the general heading of 'Wiener effect'. Some measurements of the photo-elastic properties of swollen cross-linked rubbers have recently been made in this connexion. The effect of solvent is found to be small yet significant, but its dependence on the solvent refractive index is not of the form corresponding to the simple theory put forward by Wiener. A rigorous theoretical treatment of the transmission of light through a two-component birefringent medium has been started. It has been shown that the Lorenz-Lorentz relation is not adequate to relate birefringence to anisotropy of polarizability in stretched polymer systems and that the change in local environment when a single polymer chain is stretched can make a significant contribution to the birefringence. This effect is likely to be most important in dilute solutions where individual chains scarcely interact, but the effect may also make a small contribution to the birefringence of bulk polymers.

Certain equations relating stress and flow history, derived for polymer solutions on the basis of a network model, have been used to calculate the stress components in steady shear flow and, more recently, the deformations which occur when some or all of these components are made zero[2]. Some preliminary measurements of normal stress components in steady shear flow have been made with a newly developed cone-and-plate apparatus; a diaphragm-capacity gauge with a response time of about one second is used to measure the distribution of pressure over the plate.

Two researches on the absorption of water by crystalline polymers have been started. In the first one measurements of the moisture content of a number of textile polymers in fibre and film form have been made over a wide range of humidities and temperatures. In Urquhart's work[3] it was reported that the isotherms crossed over at high relative humidities for cotton. This work, which was started after discussion with Dr. Urquhart, does not confirm this result. An attempt will be made to correlate these measurements with the 'accessibility' of these samples of material as determined by deuterium exchange with deuterium oxide. The second research is concerned with the amount of moisture taken up by cellulose after different amounts of acid hydrolysis. In the case of cotton it has been reported that the amount of moisture absorbed first decreases with time of hydrolysis, goes through a minimum and then increases, finally levelling off and becoming independent of further hydrolysis. This result has been confirmed for cotton but, in the case of viscose, no minimum has yet been found. It may be that there is a minimum for a very small amount of hydrolysis, and this aspect is being investigated. In order to interpret these results it is necessary to make certain assumptions about the crystallite size distribution, so that the work may throw further light on both the fine structure of cellulose and the mechanism of water absorption.

Experimental work to test the fundamental theory of the geometry of yarn structures has been very fruitful. Measurements have been made of the filament path in the yarn, the packing density across the yarn section and the variation in filament twist across the yarn section. Further work on the geometry is continuing and, in the next few months, a study of the relation between the mechanical properties of the yarn and those of the constituent filaments will be started. Initial experiments using rubber as a model, which has the advantage of well-defined elastic behaviour, have already been made.

An agreement has been negotiated with a firm to produce and market most of the electronic instruments developed by the Association. The prototype electronic weft-straightener has functioned to the satisfaction of a member firm and discussions for its

production are taking place. A new instrument, based on a pneumatic principle, has been developed for measuring the degree of 'raise' on raised fabrics. This instrument shows considerable promise, not only as a means of assessment, but also as a control instrument for raising machinery. The simple method of measuring warp tension in looms has been improved and instruments are undergoing tests in a number of member firms. The method may also have application in the control of tension in sizing, and suitably modified instruments are about to be evaluated in sizing machinery both at the Association and in the premises of member firms.

As mentioned earlier in this article, the work on machinery development has been restricted by internal reorganization. However, another method of controlling vibration in speed-frames has been developed and is in process of being evaluated. As for fluid beds, a full-scale single-pass bed has been constructed and this is being used for measurements of heat transfer and to assess how far laboratory data on resin-baking and dyeing are applicable under conditions approaching those in a practical machine. Apart from this, most of the development work is concentrated on designing a fluid bed suitable for dyeing fabrics constructed of hydrophobic fibres.

The number of staff is almost the same as last year. The total is 261 made up as follows: research staff, 85; laboratory and technical assistants, 75; engineering, drawing office, and maintenance staff, 60; library and administrative staff, 32; and canteen staff, 9. L. A. WISEMAN

[1] *Nature*, **179**, 1229 (1957).
[2] "Rheology of Elastomers", 79 (Pergamon, 1958). *Rheologica Acta*, No. 2 (in the press).
[3] *J. Text. Inst.*, **15**, 559 (1924).

DESIGN AND MANAGEMENT OF A NUCLEAR SCIENCE LABORATORY

By PROF. A. J. WOODALL, O.B.E., C. G. WILSON, DR. A. L. JONES and D. K. THOMAS
Royal Military College of Science, Shrivenham

THE following description of a laboratory specially designed for teaching nuclear physics and chemistry at the Royal Military College of Science, Shrivenham, may be helpful to educational institutions embarking on work in this field. This laboratory has been in full use for approximately two years and it is now possible to make some assessment of the merits of the various special features incorporated in the design.

The laboratory caters for students, who range from young officers reading for science and engineering degrees to more senior officers on specialist courses. They are mostly pressed for time and more concerned with modern applications than with the history of the subject. Accordingly, modern techniques such as electronic counting are employed in experiments on properties of radioactive substances and their radiations rather than the traditional devices such as electroscopes and electrometers. The latter still occupy an honourable position in the honours degree laboratories of the College.

The subject-matter of this course has its potential hazards; this is emphasized by maintenance of a very high standard of laboratory discipline, with proper emphasis on handling precautions and health safety techniques. Maintenance of this standard is greatly assisted by the clean lines of the light airy rooms.

The laboratory was completed, inexpensively and rapidly, by the conversion of an existing 'Romney hut', the main virtue of which was a sound concrete floor, some 75 ft. by 36 ft., protected by a semi-cylindrical water-tight shell of galvanized iron. Insertion of a false ceiling and suitable vertical divisions created rooms of normal shape and voids which provide for certain services and for the ventilation system, as indicated in the typical transverse section of Fig. 1. A substantial central wall divides the building longitudinally into physics and chemistry sections. The physics side contains a nuclear physics laboratory, a gamma-radiography room, a small counting room, a photographic dark room, a small workshop and an office. The subdivision on the chemistry side, based on ascending levels of radioactivity, provides a preparation room, a monitoring room and three radiochemical laboratories in which the anticipated level of activity is graded from negligible to dangerous. This arrangement leads to a gradation of working levels with the potentially quite dangerous activation room on the chemistry side opposite the radiography room, so that both are remote from the shielded counting room and the regions in which prolonged work is performed. The radioactive sources, in suitable individual containers, are kept in massive concrete and iron safes, one in each of the two main divisions.

The rooms are separately ventilated into the roof void above the light-alloy false ceiling, which is stiffened by overhead girders and rests on the partition walls. This system minimizes inter-

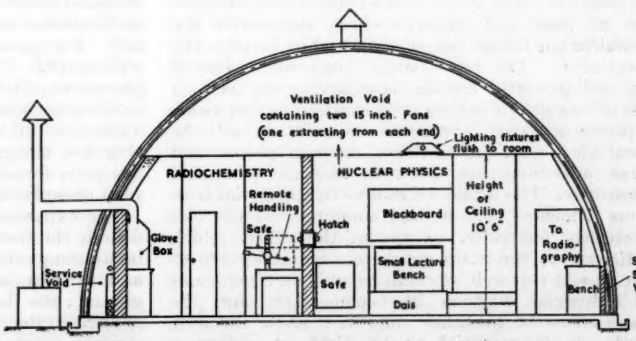

Fig. 1

change of active material between the rooms. The flow of air is governed by a pair of powerful fans and it is expelled through the original ventilating shafts on top of the building. The intake is through individual gratings to prevent one room drawing air from another. The chemistry laboratories have an additional air flow when the fume-hoods are in operation. This system could have air-filters added on the outflows if necessary. It should, however, be mentioned that current opinion inclines to make the air-flow downwards because this is assisted by the normal movement of those grosser particles which become airborne.

All exposed wall surfaces are smooth and coated with hard glossy paint, light in colour, so that splashes are easily visible. The concrete floor is completely covered with waxed polished linoleum and the joins sealed. The lighting is concealed, and all services are, whenever possible, out of sight and carried between laboratories above the false roof and inside the vertical walls. In this way surface decontamination is greatly facilitated. The main dividing wall is provided with two lead-lined hatches, so that radioactive sources can be passed from the chemistry laboratory to the physics laboratory without passing through the monitoring room.

All effluent from the monitoring room and the radiochemical laboratories passes into external delay tanks, arranged below ground-level. Such effluent is not finally discharged until the level of activity has been checked as being below the maximum agreed with the relevant authority. It should be noted that public health authorities must be consulted about all arrangements of this kind. Solid waste which might be active is put into paper bags in foot-operated medical-type waste bins. These are later sealed, and if passed for disposal, are burnt in an incinerator, remote from any habitation.

There are two neutron sources in the activation room. The larger source, an antimony–beryllium mixture with a nominal gamma-ray activity of 1 curie, is housed in a drum of paraffin wax, surrounded by a concrete cylinder built from interlocking rings with aligned holes which form vertical channels for inserting specimens for irradiation. In this way, tracer quantities of artificially radioactive materials are regularly prepared. The smaller source is of a radium–beryllium mixture, having associated gamma-activity equivalent to 20 mgm. of radium. Normally housed in a converted dustbin containing a hollow lead cylinder embedded in paraffin wax, this source is used for physical experiments involving neutrons.

Except in emergency, the monitoring room is the only means of entry to the radiochemical laboratories. Here, all staff and students check themselves for contamination before entering and when leaving the laboratories. The hand-basins have foot-operated taps, and powerful hot-air hand-dryers are used in place of towels, to reduce cross-contamination risks. All personnel wear protective overalls in all the laboratories, but, in addition, rubber gloves and canvas overshoes are worn in the radiochemical laboratories. The intake of radioactive material is so serious a hazard that eating, smoking and the like are strictly forbidden except in the office, which is adjacent to the main entrance. Since familiarity often causes research workers as well as technicians and industrial workers to become lax, and the consequences of mistakes may not show for long periods, it is essential to be rigid in enforcing this discipline, but the reasons for all rules should be fully understood and no avoidable hardship should be inflicted. For example, the hand-dryers must be very efficient so that there is no temptation to hasten operations with a surreptitious use of a handkerchief. Staff and students carry film badges and sometimes also quartz-fibre dosimeters, and a diary is maintained of individual radiation doses so recorded.

The laboratory furniture is normal, but bench tops are protected by stout water-proof waxed paper which can easily be removed after contamination. Chemical experiments are 'contained' in stainless steel trays lined with tissue paper. Normal chemical manipulation is drastically modified, there being no sniffing and tasting, while wash-bottles are replaced by plastic squeeze-bottles and pipettes are piston-operated. The preparation of sources which are powerful alpha- or beta-emitters is carried out in a glove-box, having rubber gloves sealed into apertures in the 'Perspex' windows: strong gamma-emitters are handled behind an appropriate shielding wall of interlocking lead bricks by remote handling gear. The weight of the walls is taken by the reinforced concrete bench which, incidentally, shields the lower part of the body.

Most of the apparatus on the physics side comprises various forms of radiation detector and counting equipment. The standard counting unit consists of a Geiger–Müller tube housed in a lead 'castle' and connected to a dekatron scaler by a small pre-amplifier and delay circuit. The voltage supply for the Geiger tubes is provided by power packs, each capable of feeding several units. In addition, three rate-meters are available for the direct measurement of counting rates, using end-window or liquid detectors. A pen recorder in conjunction with a rate-meter enables the decay curve of some isotopes to be traced directly. Battery-operated radiation monitors and Radiac equipment are used in simple experiments, apart from serving as laboratory monitors and survey meters. More specialized equipment includes two scintillation counters (one is incorporated in a single-channel gamma-ray spectrometer); two vibrating-reed electrometers, used for alpha-ray range determination and for ionization current measurements, etc.; and a home-made, thin-lens type, beta-ray spectrometer.

Weak radioactive sources (micro-curies) are prepared by evaporation from nickel planchettes of diluted radioactive solutions obtained from the Radiochemical Centre, Amersham. Infra-red lamps are used for this operation to avoid possible spray. The planchettes are mounted on thin 'Perspex' sheets designed to fit into a lead castle. More active sources (milli-curies) as wire or foil are obtained from Harwell. For gamma-radiography, the main source is of iridium-192 of several curies strength, used in a gamma-ray 'bomb' container. When the stronger sources are used in the exposed state in an experiment, lead brick shielding is used to ensure a reasonably low background throughout the laboratory. It has been found possible to cast suitable lead bricks very cheaply in the college workshops.

The experiments carried out in the physics section include the characteristics of the absorption of alpha-, beta- and gamma-rays; the calibration of dosimeters and of film badges; the survey of contaminated ground; the determination of beta- and gamma-ray spectra; the slow neutron flux obtained from a neutron source immersed in water; the characteristics

of Geiger and scintillation counters; the decay curves of irradiated silver; the use of nuclear emulsions; and the production of gamma-radiographs. On the chemistry side, the experiments include the production and isolation of radioactive iodine; slow-neutron activation analyses; isotopic dilution analyses; separation using exchange resins and the solubility of lead sulphate. The experiment schedules are modified to cater for the differing academic levels of students using the laboratory.

The laboratory caters for a maximum of thirty students at a time, of whom about twenty would be on the physical side and the rest doing chemical experiments. This represents a fairly high concentration of personnel in the working space, and constant vigilance is required to prevent excess local background, especially when sources are moved. Writing records of experiments is then usually carried out in a neighbouring building.

The capital cost of conversion, including benching, ventilation and drainage, for a laboratory on this scale, is likely to be in the region of £5,000; a brand-new building would cost much more and take longer to construct. Equipment at the standard adopted for this laboratory is comparable in cost. It is felt that the high initial cost of carefully chosen commercial apparatus has been fully justified in the sequel by the excellent service it has given and by the low maintenance costs.

We wish to record our indebtedness to those members of the Atomic Energy Research Establishment and the Atomic Weapons Research Establishment, who were consulted during the planning stage, for their valuable advice and to the Garrison Engineer at Shrivenham and his staff for their co-operation and professional skill. To those who contemplate similar ventures we would warmly recommend a close study of laboratories of high standard. There are many points of detail which cannot be included in an account of this kind, but which make a difference to smooth and efficient running of the laboratories and reduce the risk of accident. The close co-operation of physicist and chemist in the design and operation of the laboratory has played a notable part in promoting its efficiency and its usefulness to the students, who gain a more balanced picture of the subject in this way.

THE ELECTRICAL RESEARCH ASSOCIATION

THE Electrical Research Association has recently completed its first year of work, under the direction of Dr. H. G. Taylor, at the new laboratories at Leatherhead. Changes and developments are reflected in some measure in the form as well as in the content of the annual report for 1957* which was presented at the annual general meeting held on May 7.

It is with regret that we record the death, on the day of the meeting, of Mr. F. H. Bramwell, chairman of the Council of the Association, over whose signature the report of the Council appears in the annual report.

In the matter of framing research policy it is noteworthy that the Council now has the benefit of drawing upon the knowledge and experience of an Advisory Research Board, the constitution of which is given in the report under the list of committees and panels. On the administrative side a new post of research manager has been established and is occupied by Mr. L. Gosland, who was formerly head of the switchgear department.

In order to form some assessment of the extent to which the Association's research effort is co-ordinated with the interests of members, a questionnaire was issued during the year inviting opinion as to the application of the Association's research funds. The results were weighted in relation to the value of members' subscriptions and a final percentage analysis prepared. This analysis is found to be in reasonably good correlation with the relative scale of the Association's activity in its various fields, and although it does not show a pressing demand for work in any field in which the Association is not at present engaged, there is a significant emphasis on the subject of the nuclear irradiation of dielectrics, cathodic protection, climate proofing, nuclear power and semi-conductors. The results of this questionnaire provide very useful guidance for future policy.

Mention is made of the difficulties which have been experienced in filling vacancies on the senior scientific staff and of the efforts which are being made to interest young university graduates in engineering and in physics in the work of the Association. The total number of staff employed by the Association at the end of the year under review was 348.

In the field of insulation, which constitutes one of the major areas of the Association's work, a result of considerable practical significance has been obtained in the demonstration of the importance of moisture content in controlling the discharge inception-level of cellulose. Confirmation has also been obtained, in the case of one of the new high-density polyethylenes, of the recently propounded electro-mechanical theory of breakdown.

It is interesting to note that it has been found desirable to initiate a fundamental study of the mechanism of oxidation of hydrocarbon oils. This programme is being carried out in three university departments. The need to supplement the great body of existing knowledge of the behaviour of hydrocarbon oils as insulants for electrical apparatus arises from the urge to raise the working temperature of transformers.

In another important branch of the Association's work, that of circuit breakers and circuit-breaking phenomena, progress is reported in the breaking of both low and high currents in vacuum and, in relation to the arc itself, theoretical predictions of high arc-core temperatures (35,000° K.) have been confirmed by spectroscopic measurements.

Two interesting full-scale experiments relating to electric power systems are reported. These were carried out in collaboration with the Central Electricity Authority. The stability of a large national electricity supply system under conditions of overload or of transient disturbance is naturally a matter of

* Electrical Research Association. Thirty-seventh Annual Report for the year ended 31st December, 1957. Pp. 119+8 plates. (Leatherhead: Electrical Research Association, 1958.)

importance and studies of system stability are made using network models known as network analysers. The validity of the results of such studies is in large measure dependent upon the correctness of the values of the system constants used in setting up the model system, and these have often to be based on indirect computation. There is therefore great interest in the carrying out of stability tests on actual power systems whenever such full-scale tests can be arranged. The first large-scale experiments on system stability to be made in Britain were carried out during a Bank Holiday week-end at the Cliff Quay Generating Station of the Central Electricity Authority. The performance of the system was predicted on three models, the network analysers of the Association and of the Associated Electrical Industries organization together with the 'Micro Réseau' of Electricité de France. The results of these tests will be communicated in a group of papers to be read before the Institution of Electrical Engineers. It is, however, stated in the report that the behaviour of the system was in general agreement with prediction.

The second experiment concerned the strength of the foundations of transmission towers. The opportunity to make tests on a series of erected towers occurred as a result of the decision of the South Eastern Electricity Board to discontinue the use of a section of 33 kV. line in the Guildford area. Mechanical loading tests were carried out on the towers with the view of determining the strength of their foundations. The report on these tests has not yet been issued, but it is stated that the strength of the foundations was considerably less than had been expected.

The Association's work on intrinsically safe circuits for measurement and control in an atmosphere of explosive gases has included acetylene and ethylene. As a result of this, ethylene has been included in the list of gases covered by the appropriate British Safety Standard, and certification is now available for apparatus to be used in an ethylene atmosphere.

An attractive new feature of the annual report is the inclusion of a group of photographs illustrating aspects of the research work. One of these is a reproduction of a thunderstorm distribution map for 1957 for England, Wales and Scotland. The accumulation by the Association of data concerning lightning flashes is proving to be of increasing value. Towards the end of the report is given a list of universities, colleges, Government establishments and national authorities in which the extramural research of the Association is being carried on, in each case stating the subject of the research programme and names of those responsible for the work. J. Greig

GENETICS OF BETA-GLOBULIN POLYMORPHISM IN BRITISH CATTLE

By G. C. ASHTON

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In a preliminary communication five serum β-globulin phenotypes of cattle, identified by starch gel electrophoresis, were described[1]. A sixth phenotype has now been found, and as a result it is possible to propose a genetic mechanism for the system.

The six phenotypes are shown in Fig. 1 together with the postulated genotypes. The mating data and symmetrical appearance of the phenotypes suggested that a three-allele system (genes β^A, β^D, and β^E) with no dominance is operative. The homozygotes type I (β^A/β^A), type IV (β^D/β^D), and type VI (β^E/β^E) are individually recognizable. The heterozygotes are also recognizable as such; thus type II (β^A/β^D) is clearly a composite of types I and IV, type III (β^D/β^E) a composite of types IV and VI, and type V (β^A/β^E) a composite of types I and IV. Equal mixtures of the appropriate homozygous β-globulin sera are indistinguishable qualitatively from genuine samples of heterozygous serum when run side by side. Each of the phenotypes I–VI is thus a single genotype, and it is therefore appropriate to discard the numerical terminology and name each phenotype by its genotype. The expected distribution of phenotypes (genotypes) is shown in Table 1, while pooled mating data for a number of breeds are shown in Table 2. The expected and observed results agree when tested by the χ^2 test.

In the preliminary communication[1] only five phenotypes had been recognized, and to fit the mating data reported at that time it was necessary to postulate a series of linked genes. However, with the finding of the sixth phenotype (β^{EE}) the genetic mechanism became clear and it was apparent that five of the 150 matings previously reported[1] (two I × IV → I; one I × IV → IV; one III × V → I; one III × V → IV) were not possible on the 3-allele

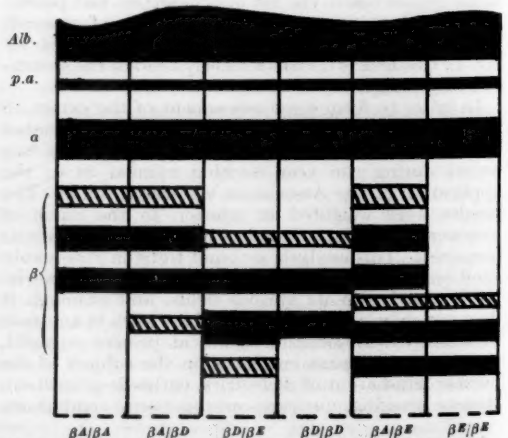

Fig. 1. The six β-globulin types. *Alb.*, albumin; *p.a.*, post albumin; α, α-complex; β, β-globulins. Solid bands, intense staining; cross-hatched, less intense

Table 1. Expected Mating Results and Distribution of Offspring on Three-allele Theory

Parents	Distribution of offspring					
	β^{AA}	β^{AD}	β^{DE}	β^{DD}	β^{AE}	β^{EE}
$\beta^{AA} \times \beta^{AA}$	1·0	—	—	—	—	—
,, β^{AD}	0·5	0·5	—	—	—	—
,, β^{DE}	—	0·5	—	—	0·5	—
,, β^{DD}	—	1·0	—	—	—	—
,, β^{AE}	0·5	—	—	—	0·5	—
,, β^{EE}	—	—	—	—	1·0	—
$\beta^{AD} \times \beta^{AD}$	0·25	0·5	—	0·25	—	—
,, β^{DE}	—	0·25	0·25	0·25	0·25	—
,, β^{DD}	—	0·5	—	0·5	—	—
,, β^{AE}	0·25	0·25	0·25	—	0·25	—
,, β^{EE}	—	—	0·5	—	0·5	—
$\beta^{DE} \times \beta^{DE}$	—	—	0·5	0·25	—	0·25
,, β^{DD}	—	—	0·5	0·5	—	—
,, β^{AE}	—	0·25	0·25	—	0·25	0·25
,, β^{EE}	—	—	0·5	—	—	0·5
$\beta^{DD} \times \beta^{DD}$	—	—	—	1·0	—	—
,, β^{AE}	—	0·5	0·5	—	—	—
,, β^{EE}	—	—	1·0	—	—	—
$\beta^{AE} \times \beta^{AE}$	0·25	—	—	—	0·5	0·25
,, β^{EE}	—	—	—	—	0·5	0·5
$\beta^{EE} \times \beta^{EE}$	—	—	—	—	—	1·0

Table 2

Parents	Distribution of 325 single offspring					
	β^{AA}	β^{AD}	β^{DE}	β^{DD}	β^{AE}	β^{EE}
$\beta^{AA} \times \beta^{AA}$	13	—	—	—	—	—
,, β^{AD}	23	30	—	—	—	—
,, β^{DE}	—	3	—	—	4	—
,, β^{DD}	—	42	—	—	—	—
,, β^{AE}	5	—	—	—	3	—
,, β^{EE}	—	—	—	—	2	—
$\beta^{AD} \times \beta^{AD}$	10	14	—	8	—	—
,, β^{DE}	—	1	2	1	3	—
,, β^{DD}	—	32	—	39	—	—
,, β^{AE}	3	3	4	—	1	—
$\beta^{DE} \times \beta^{DE}$	—	—	7	3	—	2
,, β^{DD}	—	—	6	12	—	—
,, β^{AE}	—	1	3	—	1	3
$\beta^{DD} \times \beta^{DD}$	—	—	—	27	—	—
,, β^{AE}	—	4	2	—	—	—
,, β^{EE}	—	—	4	—	—	—
$\beta^{AE} \times \beta^{AE}$	1	—	—	—	2	1

No matings between β^{EE} and β^{AD}, β^{DE}, β^{AE} or β^{EE} have been observed

theory indicated by the sixth phenotype. These mating results were re-investigated and in each case proved to be false after critical examination. In this connexion Rendel[2] found that the stated parentage was in error in about 8 per cent of sire-dam-offspring families blood-grouped in Sweden. It is thus probable that the β-globulin system will be of assistance in checking parentage.

The five phenotypes previously reported[1] were found independently by Smithies and Hickman[3]; on the basis of 71 mating results within two herds they postulated a three-gene theory for cattle β-globulins also, although their interpretation of the expression of each gene has proved to be incorrect.

In order to establish reliable gene frequency data for each breed of cattle it is necessary to examine a representative cross-section of each breed. It is difficult to get a truly random sample by examining cattle indiscriminantly, due to the preponderance of herds using one or two bulls only. However, with the advent of artificial insemination representative groups of pedigree bulls drawn from many sources have been established, and these bulls each serve many hundreds of cows and heifers every year.

Table 3 shows the distribution of phenotypes in bulls standing at Milk Marketing Board cattle-breeding centres compared with bulls standing at other centres.

Gene frequencies for each breed from both groups of centres are shown in Table 4. The results were calculated from the relationships, $A = (2\beta^{AA} + \beta^{AD} + \beta^{AE})/2N$, $D = (\beta^{AD} + \beta^{DE} + 2\beta^{DD})/2N$, and $E = (\beta^{DE} + \beta^{AE} + 2\beta^{EE})/2N$, where β^{AA}, β^{AD}, etc. are the numbers of animals of this phenotype found for any given breed and N is the total number of animals, and where A, D and E are the frequencies of genes β^A, β^D and β^E respectively. The standard errors of the gene frequency estimates were calculated from the expression $\sqrt{1/2N.\ [g(1-g)]}$, where g is gene frequency.

It will be seen that the gene frequencies calculated from both groups of breeding centres are consistent for each breed, within the standard errors found. The gene frequencies found for each breed, therefore, are probably fairly representative for that breed in Britain.

It is evident that the frequency of β^E is greater in those breeds originating in the climatically more severe parts of the British Isles. Thus β^E is absent in Jersey, Guernsey, Devon and South Devon cattle, confined mainly to the south and south-west of England, while it is most frequent in cattle of Scottish origin. Furthermore, the frequency of this gene within the Ayrshire breed is associated with the location of the herd. In a herd using artificial insemination selected at random in Essex the frequency of β^E was $0{\cdot}118 \pm 0{\cdot}025$ (80 animals), which is in agreement with the expected value (cf. Table 3). In a comparable herd (67 animals) in Aberdeenshire, on the other hand, the frequency of β^E was $0{\cdot}261 \pm 0{\cdot}037$, while Hickman and Smithies[3] found a frequency of $0{\cdot}279 \pm 0{\cdot}049$ in an Ontario Ayrshire herd (42 animals). These results suggest that β-globulin polymorphism in cattle may be concerned with climate

Table 3. Distribution of Phenotypes of 808 Pedigree Bulls at Cattle-Breeding Centres

Breed	Origin*	Distribution of phenotypes					
		β^{AA}	β^{AD}	β^{DE}	β^{DD}	β^{AE}	β^{EE}
Friesian	*M*	58	85	8	54	9	0
	O	9	16	1	14	7	0
Shorthorn	*M*	42	42	1	18	5	0
	O	16	11	0	6	0	0
Hereford	*M*	16	21	1	27	1	0
	O	3	2	0	6	0	0
Ayrshire	*M*	6	26	14	32	3	0
	O	3	16	3	18	3	0
Aberdeen Angus	*M*	18	7	0	4	9	0
	O	5	4	1	2	2	0
Guernsey	*M*	10	19	—	8	—	—
	O	6	11	—	8	—	—
Jersey	*M*	17	15	—	4	—	—
	O	7	5	—	1	—	—
Devon	*M* and *O*	5	7	—	12	—	—
South Devon	*M* and *O*	1	4	—	9	—	—
Galloway	*M*	0	1	0	0	1	2

* *M*, Milk Marketing Board cattle-breeding centres (22); *O*, other cattle-breeding centres (9).

Table 4. Frequencies of Genes β^A, β^D and β^E and their Standard Errors

Breed	Origin*	Gene frequencies			Standard errors ±		
		β^A	β^D	β^E	β^A	β^D	β^E
Friesian	*M*	0·490	0·470	0·040	0·024	0·024	0·062
	O	0·436	0·479	0·085	0·051	0·052	0·029
Shorthorn	*M*	0·606	0·366	0·028	0·032	0·033	0·011
	O	0·651	0·349	0·000	0·058	0·058	—
Hereford	*M*	0·409	0·576	0·015	0·043	0·043	0·011
	O	0·364	0·636	0·000	0·102	0·102	—
Ayrshire	*M*	0·253	0·642	0·105	0·041	0·038	0·024
	O	0·291	0·639	0·070	0·049	0·052	0·028
Aberdeen Angus	*M*	0·684	0·198	0·118	0·075	0·065	0·017
	O	0·572	0·321	0·107	0·106	0·100	0·066
Guernsey	*M*	0·527	0·473	—	0·058	0·058	—
	O	0·460	0·540	—	0·071	0·071	—
Jersey	*M*	0·681	0·319	—	0·055	0·055	—
	O	0·792	0·208	—	0·083	0·083	—

* *M* and *O* as in Table 3.

tolerance. It is significant that the average heat adaptability coefficients of some breeds of cattle, quoted by Findlay[4], are in inverse order to the β^E frequencies; for example, Jersey adaptability coefficient 79, β^E nil; Hereford 73, β^E 0·013; Aberdeen Angus 59, β^E 0·115. In view of the high adaptability coefficient (89) of Brahman cattle, it will be worth while investigating the β-globulins of these animals.

It is noteworthy that recently described β-globulin polymorphism in humans sharply distinguishes the black and white races[5]. Polymorphism involving the β-globulins has also been found in sheep[6], goats, horses and rhesus monkeys[7]. This may prove to be one mechanism, therefore, by which a species is able to adapt itself to both temperate and tropical climates.

I gratefully acknowledge the co-operation of the veterinary officers and managers of the various artificial insemination centres in sending samples of bull blood, and of Mr. W. Thomson, of the Duthie Experimental Stock Farm, Aberdeenshire, for supplying blood samples from Ayrshire cattle. I am indebted to Mr. J. C. Gower of Rothamsted for help with the calculation of gene frequencies and errors.

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GROUP-TRANSLOCATION: A CONSEQUENCE OF ENZYME-CATALYSED GROUP-TRANSFER

By Dr. PETER MITCHELL and Dr. JENNIFER MOYLE
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RECENT research on bacterial permeability[1], metabolism[1,2] and adaptation[2] has shown that the kinetics of the passage of metabolites through the plasma-membrane of bacteria closely resembles enzyme kinetics; and it has been inferred that certain protein components of the plasma-membrane may act as highly specific conductors of membrane-transport. We have suggested that normal enzyme systems are the conductors of membrane-transport and that metabolic energy is generally converted to osmotic work by the formation and opening of covalent links between enzymes or co-enzymes in the membrane and the transported 'molecules' that are carried as chemical groups exactly as in enzyme-catalysed group-transfer reactions[1,3]. This view has been supported by the observation that the plasma-membrane of certain bacteria is partly constituted of normal enzymes and carriers[4]. On the other hand, using a less direct but very elegant approach to the problem, Cohen and Monod have recently adopted a view that they attribute to Danielli[5]. They suppose that "the rapid permeation of hydrophilic organic compounds into cells is ensured by stereospecific and functionally specialized protein components of the plasma-membrane". They have introduced the word 'permease' to distinguish these supposedly functionally specialized catalysts of facilitated diffusion and also of active transport from metabolic enzymes, and have thus retained the old problem of the mechanism of energy coupling between metabolism and the catalysts of the osmotic processes.

The object of the present communication is to amplify our own conception of the connexion between normal enzyme catalysis and the movement of chemical groups in space[3], and to demonstrate again in a more general context that the active transport of metabolites can be adequately explained in orthodox biochemical terms.

The recent developments on the border between enzyme kinetics and metabolic enzymology have led to a spatially more realistic description of enzyme catalysis than was generally accepted before, by focusing attention upon the enzymic transfer of chemical groups and by considering the enzyme as a reactant in group-transfer reactions[1,7]. For example[7], certain phosphokinases (E) are believed to mediate in the transfer of phosphoryl between adenosine triphosphate (ATP) and the substrate (S) being phosphorylated (forming EP) as follows:

$$ATP + E \rightleftharpoons ADP + EP$$
$$EP + S \rightleftharpoons E + SP$$

Evidently there must be a spatial movement (translocation) of phosphoryl relative to adenosine diphosphate and the substrate in relation to the enzyme molecule as represented in Fig. 1, supposing the reaction to be on the enzyme 'surface', or as in Fig. 2 supposing the reaction to occur in a cleft in the molecule—the movement of phosphoryl from adenosine diphosphate to the substrate possibly involving thermal distortion of the enzyme itself as suggested previously[3]. The group-translocation accompanying group-transfer illustrated by this example is, we suggest, a phenomenon general to many enzyme-catalysed group-transfer reactions, including hydrogen and electron transfer. The translocation implicit in the transfer process would, of course, have no macroscopic effect in a homogeneous system and might, under these conditions, be passed over as unimportant. If the system is not

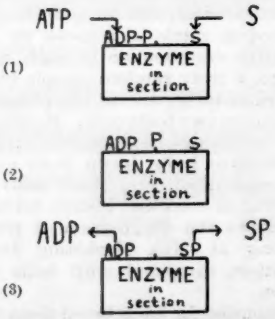

Fig. 1

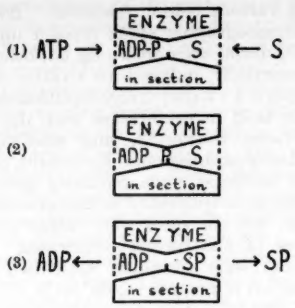

Fig. 2

homogeneous, however, group-translocation may have a biochemically important macroscopic consequence.

It is possible to envisage both a macroscopic and a microscopic type of inhomogeneity that may cause group-translocation to show macroscopically. In the macroscopic type, the enzyme molecules must be orientated in a membrane in such a way that certain components react with the active centre from one side (or from both sides) while one or more other components react only from the other side. The essential consequence of this state of affairs would be that a chemical group must pass across the membrane during the enzyme-catalysed reaction. The enzyme as depicted in Fig. 2 could give rise to the effect that we are describing simply by being imbedded in an inert osmotic barrier with the cleft connecting the phases on either side; and even the more usual representation (Fig. 1) would give rise to the same effect if the enzyme molecules were orientated so that the part of the osmotic barrier lying close to the active centre formed a cleft connecting the phases on either side like that envisaged in the enzyme itself in Fig. 2. In this way, membrane-transport and metabolism can be integral consequences of the same enzyme-catalysed process.

The microscopic type of inhomogeneity that may cause group-translocation to be macroscopically significant requires the participation of a second enzyme that can catalyse a change in the product of the first enzyme reaction. In this case we can visualize the inhomogeneity as a pairing of the different enzyme molecules so that a product of the first enzyme reaction diffuses to the active centre of the second enzyme faster than it escapes into the neighbouring region of the medium. The possible consequences of this type of inhomogeneity are of more than theoretical interest, because the grouping of enzymes and carriers into double- or many-functional particles within which the reactions are closely integrated is well known[8].

The highly organized particle and membrane systems of most animal and plant cells recently discovered have presented new problems of spatial metabolic organization that have taxed the imagination of biochemists[8]. We suggest that the concept of group-translocation may provide the basis for a new but essentially orthodox biochemical approach to these problems. A more detailed account of group-translocation will be published in due course[9].

We would like to thank the Scottish Hospital Endowments Research Trust for personal grants in support of our work.

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OXIDATIVE METABOLISM OF POLYCYCLIC HYDROCARBONS BY SOIL PSEUDOMONADS

By H. N. FERNLEY and Prof. W. C. EVANS

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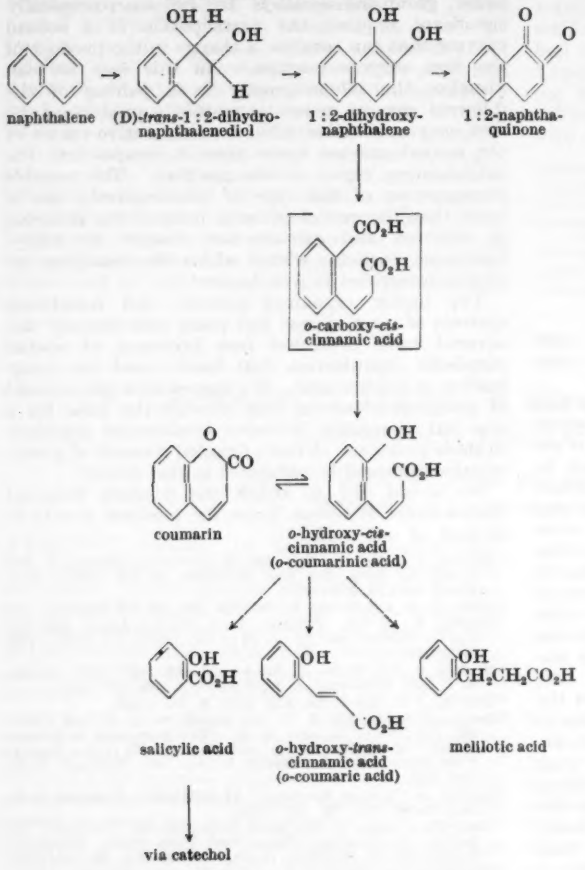
THE intermediary pathways through which monocyclic aromatic compounds are metabolized by soil bacteria have been summarized by Evans, Smith, Linstead and Elvidge[1]. It has been known since the work of Tausson[2] that several polycyclic hydrocarbons, for example naphthalene, anthracene and phenanthrene, also serve as substrates for certain soil organisms and are metabolized completely. A knowledge of the precise method of biochemical attack on these polynuclear hydrocarbons may help towards understanding the microbial oxidation of naturally occurring condensed ring systems.

In naphthalene cultures of a *Pseudomonad* strain, Strawinski and Stone[3] identified salicylic acid; Walker and Wiltshire[4], in addition, isolated D-*trans*-1 : 2-dihydro-1 : 2-dihydroxynaphthalene, and showed by the sequential induction technique that both were intermediates in the metabolism of this hydrocarbon. The latter workers also studied the breakdown of 1-chloronaphthalene[5] by a suitable organism, identifying 8-chloro-1 : 2-dihydro-1 : 2-dihydroxynaphthalene and 3-chlorosalicylic acid as intermediates. These results made it very probable that C-5 in 1-chloronaphthalene became the carboxyl-C of 3-chlorosalicylic acid. Murphy and Stone[6] found that 1 : 2-naphthaquinone accumulated, eventually in toxic amounts, in naphthalene cultures of their strain of *Pseudomonas*.

Recently, Rogoff and Wender[7,8] have shown that phenanthrene and anthracene are also metabolized through end-ring attack, by members of the genus *Pseudomonas*. Thus, from phenanthrene cultures

Scheme 1. Suggested Pathway for the End-ring Attack on Naphthalene by Soil *Pseudomonads*



they isolated 1-hydroxy-2-naphthoic acid, while anthracene cultures afforded 3-hydroxy-2-naphthoic acid, as intermediates. Both these acids were afterwards metabolized through salicylic acid into the catechol pathway, as shown by sequential induction experiments.

The ultimate product of end-ring fission in the microbial metabolism of polycyclic hydrocarbons is therefore salicylic acid or an analogue. Intermediate stages in the breakdown of the end-ring have not, however, been ascertained.

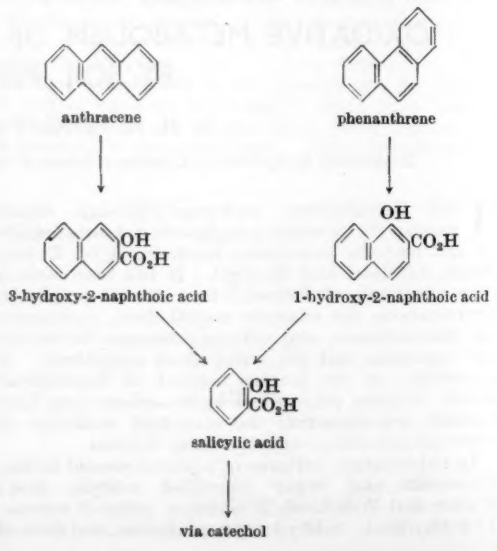
Cultures of a *Pseudomonad* strain isolated from conifer litter, growing aerobically in a simple mineral salts medium[9] with naphthalene as sole substrate, gave coumarin from the acid-ether fraction, detected by smell, and identified by chromatography, absorption spectrum ($\lambda_{max.}$, 277 mμ in water), and mixed melting-point with an authentic sample. It would appear that *o*-hydroxy-*cis*-cinnamate is the actual metabolite present in culture and not coumarin itself, since this would have occurred in the neutral-ether fraction, which was not the case. These cultures also contained, at various times, detectable amounts of *o*-hydroxy-*trans*-cinnamic acid (*o*-coumaric acid), *o*-hydroxyphenylpropionic acid (melilotic acid), and salicylic acid, as shown by their chromatographic separation, fluorescence, absorption spectra, and various colour reactions. Some minor chromatographic spots remain unidentified.

Bacterial cells grown on naphthalene were sequentially induced to oxidize *trans*-1 : 2-dihydro-1 : 2-dihydroxynaphthalene and salicylic acid in accordance with the results of previous workers[4,5], and also to 1 : 2-dihydroxynaphthalene. Coumarin, *o*-coumaric and melilotic acids regularly gave oxygen-uptakes considerably in excess of the control cells, but the rates were rather slower than those of the former substrates. Negative results were obtained with two synthetic *o*-carboxycinnamic acids (m.p. 175° C. and 197–205° C. respectively[10,11]), *o*-carboxyphenylpropionic acid, phthalide acetic acid, *o*-carboxybenzoylacetic acid, and phthalic acid.

A crude cell-free extract prepared from naphthalene-grown cells rapidly oxidized pure 1 : 2-dihydroxynaphthalene, with the consumption of approximately 3 atoms of oxygen, and the liberation of 1 mole of carbon dioxide per mole of substrate. Coumarin was isolated as the major product of this enzyme action, on acidification and ether extraction. By analogy with previous work in this field[1], the immediate product of ring fission is presumably *o*-carboxy-*cis*-cinnamate, but we have no evidence, as yet, of its formation. Neither of the synthetic *o*-carboxycinnamates is acted upon by this crude enzyme preparation, but this may be because they are both varieties of the *trans*-isomer, whereas the bacterial enzyme would be expected to be stereo-specific towards the *cis*-form[12]. The production of *o*-hydroxy-*cis*-cinnamate (isolated as coumarin) is explained by an oxidative decarboxylation of the presumed labile *o*-carboxy-*cis*-cinnamate; the molar gaseous exchange is in agreement with this view.

On the basis of these results, the oxidative

Scheme 2. Suggested Pathway for the Dissimilation of Anthracene and Phenanthrene by Soil *Pseudomonads* (ref. 8)



microbial metabolism of the end-ring of naphthalene is suggested as proceeding according to the pathway shown in Scheme 1. Naphthalene is first oxidized to the D-*trans*-dihydronaphthalenediol, which is normally dehydrogenated to 1 : 2-dihydroxynaphthalene prior to ring fission, but in certain circumstances (depending on the organism and cultural conditions) further oxidation to the toxic 1 : 2-naphthaquinone occurs. Ring cleavage of 1 : 2-dihydroxynaphthalene is assumed to proceed through *o*-carboxy-*cis*-cinnamate, which is oxidatively decarboxylated to *o*-hydroxy-*cis*-cinnamate. The other related products identified in naphthalene cultures could arise by well-known biochemical reactions from this key intermediate, for example: (*a*) by β-oxidation salicylic acid, afterwards to be metabolized via catechol[13], (*b*) isomerization and reduction, *o*-coumaric and melilotic acids, afterwards to be metabolized by an unknown route.

Our present information as to the pathway of oxidative microbial metabolism of anthracene and phenanthrene is shown in Scheme 2 after Rogoff and Wender[8]. End-ring attack may occur in an analogous manner to that of naphthalene, through the cleavage of 1 : 2-dihydroxyanthracene, and 3 : 4-dihydroxyphenanthrene respectively.

It will be a future task to elucidate the enzymology of this metabolic sequence, and to explore its relevance to the breakdown of polycyclic compounds in general.

H. N. Fernley thanks the Agricultural Research Council for its support.

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ETCHING OF RADIATION DAMAGE IN LITHIUM FLUORIDE

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FROM experiments on the coloration induced in potassium chloride by fission fragments allowed to recoil into the crystal, it was proposed[1] that the unannealed recoil tracks consist of individual and aggregated lattice defects with trapped positive holes and electrons. During optical bleaching of the *F*-band, the *F*- and electron-excess centres aggregate to form *R*′-centres along the core of the damage produced by the recoiling fragment, and it was suggested that in respect of chemical properties, that is, precipitation, the recoil track is similar to a heavily jogged dislocation.

The damage produced in ionic crystals by recoiling fission fragments from an external source has now been examined by another technique. It was argued that the thermodynamic potential of the crystal should be increased around those regions of the surface at which the fission fragments are injected, and that this should manifest itself in an enhanced rate of dissolution with respect to the undamaged crystal surface. That is to say, etch-pits should be formed as at dislocations. Accordingly, single crystals of lithium fluoride were cleaved along the {100} plane and fission fragments from a U_3O_8-film 1 mm. distant allowed to enter a portion of the crystal surface at room temperature. The crystals were then etched in the mixture of concentrated hydrofluoric acid (1 part) and glacial acetic acid (1 part) saturated with ferric fluoride, which was recommended for the purpose by Gilman and Johnstone[2]. After etching without agitation for between 1 and 42 min. at 12° C., the crystals were washed in absolute alcohol and dry ether, dried in a warm air current and photographed under oblique illumination in a Vickers projection microscope.

The crystal illustrated in Figs. 1–4 was exposed to a total thermal neutron dose of 3×10^{10} cm.$^{-2}$, which corresponds to a fission fragment dose of 1×10^7 recoils per cm.^{2} of crystal surface. Etching times and magnifications are given in the legends. A general view of the boundary of the bombarded region is shown in Fig. 1 and an expanded view of part of the boundary is shown in Fig. 2 at an earlier stage of the etching. From this latter photograph it may be calculated that the etch-pit density is 8–9 $\times$ 10^6 cm.$^{-2}$, from which it appears that one etch-pit is formed for each fission fragment after allowance is

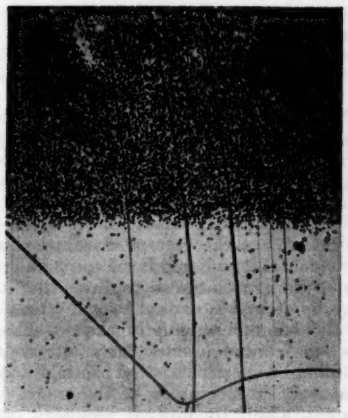

Fig. 1. General view of the boundary of the bombarded region. 32 min. etch. (× 60)

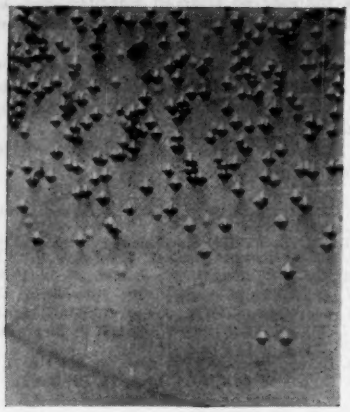

Fig. 2. Expanded view of a section of the boundary of the bombarded region. 8 min. etch. (× 640)

made for overlap. No new phenomena are introduced as the density of fission fragments is increased to 10^{12} cm.$^{-2}$, and at no stage has any effect of the $^6Li(n,\alpha)^3H$ reaction been observed, though even in the photographed crystal some 10^8 n,α events cm.$^{-2}$ must have occurred within recoil range of the surface. Even heavily bombarded surfaces (10^{12} fission fragments per cm.^{2}) reveal no sputtering or surface structure before etching. So far as etching is concerned, the damage appears to anneal out completely between 450 and 500° C., as suggested by the results of Smallman and Willis[3]. There is no evidence of polygonization during gentler annealing treatments.

When small ($< 1\mu$), the etch pits grow more rapidly than when they are large, and commonly exhibit central depressions, as shown in the electron micrograph, Fig. 3*a*. Other electron micrographs, Figs. 3*b* and *c*, clearly show that the walls of the etch pits consist of finely spaced terraces and are not planar, the walls becoming steeper towards the centre of the pit. As the pits grow larger, the rate of linear growth is reduced. Two types of growth appear to be possible. Some pits remain fairly shallow over most of their area, but retain a central depression, whereas others, in the minority, grow as deep regular square pyramids throughout their lives. Examples of both types of growth are shown in Figs. 2 and 4. We therefore propose that in the case of etching recoil tracks, the initial process is a rapid dissolution of highly disordered material at the centre of the track. This rapid dissolution permits the development of crystal faces which are not necessarily those of lowest surface free energy though they have the correct symmetry for the {100} face. Rapid dissolution continues until the etch pit exceeds the boundary of the track, when the normal crystal structure determines the rate of dissolution and the angles at which the etch pit faces meet the surface. It is also of general interest to note that damage which may be etched is caused even by fission fragments at the commencement of their tracks. This means that we cannot assume, as is often done for energetic charged particles, that simple ionization predominates at the beginning of the track. Lattice displacements, albeit by mutual repulsion of highly ionized constituents, are important at the beginning of a fission fragment track.

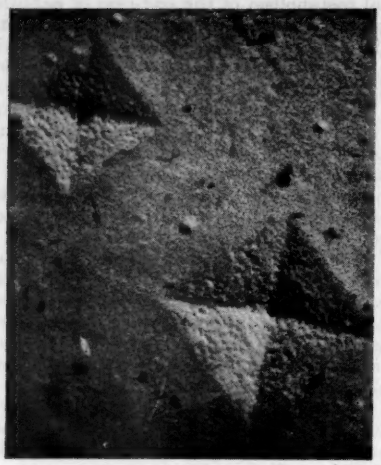

Fig. 3*a*. Electron micrograph of two typical pits. The replica was made of 'Formvar' shadowed normally with carbon and at 45° with palladium–gold. 1 min. etch. (× 13,300)

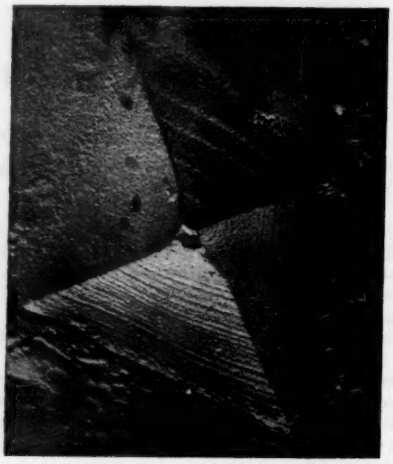

Fig. 3*b*. Electron micrograph of a small pit, showing the terraced faces. The cube directions are parallel to the etch pit diagonals. 1 min. etch. (× 13,300)

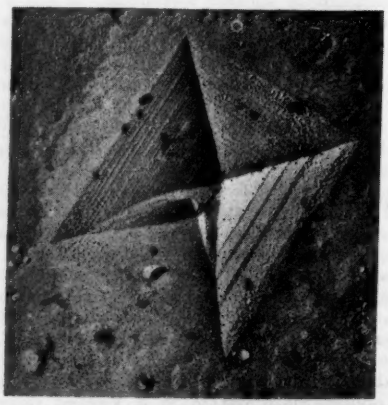

Fig. 3*c*. Electron micrograph of a twin pit showing terraced faces. 1 min. etch. (× 10,000)

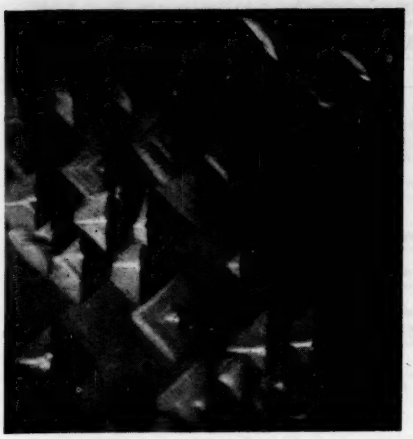

Fig. 4. Optical micrograph of the bombarded surface after soaking for 42 min. in the unstirred etch solution. (× 1,260)

If the above argument is qualitatively correct, the region of substantial lattice damage around the fission recoil track may reach a diameter of about 5000 A. in lithium fluoride. We conclude from the absence of polygonization and the low energy input, which is insufficient to raise the temperature of the surface layers even by 0·1° C., that classical dislocations are not formed in lithium fluoride by recoiling fission fragments and that we are dealing with linear regions of lattice damage, although in potassium bromide there is some evidence for the production of dislocations by this means.

A further development of interest is noted after prolonged soaking without agitation of the bombarded crystals in the etch solution. Fig. 4 is an optical micrograph (× 1,260) of etch pits developed in the unstirred reagent in 42 min. at 12° C. It will be seen that although some of the pits are regular square pyramids, others have developed a small number of pronounced steps. Similar pits have been observed by Whapham for etch pits originating on dislocations, and in explanation he has suggested that a dislocation inadvertently introduced during rough handling may become trapped at the centre of a flat pit formed at an earlier stage. This mechanism appears realistic in the case of flat-bottomed etch pits originating at dislocations which have afterwards moved on along a slip line, but can scarcely apply to pits originating at recoil tracks.

Noting that small, rapidly formed etch pits show a regular terraced structure, we propose that these terraces are probably composed of {100} planes parallel to the crystal surface and {110} planes normal to the crystal surface. On prolonged soaking the relative areas of these planes become redistributed in favour of decreasing {110} area even in the absence of overall dissolution. According to the estimates of van Zeggeren and Benson[4], the surface energies, not allowing for surface polarization, are 832 and 169 ergs cm.$^{-2}$ for the {110} and {100} faces, respectively. This is quite consistent with the view that a regular square pyramidal pit in contact with mother liquor is inherently unstable and will eventually break down into a large flat-bottomed pit containing a small pit at the centre.

I am indebted to Dr. W. M. Lomer and to Dr. A. D. Whapham for useful discussions. Mr. J. A. Coiley took the electron micrographs.

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EFFECT OF HYALURONIDASE ON CAPILLARY PERMEABILITY, LYMPH FLOW AND PASSAGE OF DYE-LABELLED PROTEIN FROM PLASMA TO LYMPH

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ACCORDING to previous reports[1–3] hyaluronidase seems to exert a distinct effect on the capillaries, increasing their permeability. This assumption, however, is not definitely proved. Hæmoconcentration, increased loss of fluid and of injected dyestuff from the circulation produced by hyaluronidase can equally well be accounted for by intravascular pooling of blood plasma[4,5].

Proteins leaving the circulation appear in the extravascular fluid. Tissue fluid, which forms the greater part of the extravascular fluid, can, under normal conditions, scarcely if ever be collected in sufficient amounts for analysis. Colloidal molecules entering the extracellular fluid also appear almost instantaneously in the lymph. We hoped, therefore, to obtain further information on the effect of hyaluronidase by investigating the composition and flow of lymph.

All investigations were carried out on dogs under hexobarbital anæsthesia (0·1 gm./kgm.). In the first series we tapped the thoracic duct in the neck and also the cervical lymph trunks on both sides with plastic tubes. In the second series of investigations lymph was collected from the lymphatics of the liver and the small intestine. The dogs received 1,000 V.R.U. of bacterial hyaluronidase (Hyason Organon) intravenously, followed immediately by 0·1 ml./kgm. of a 0·1 per cent solution of Evans blue, also intravenously. Lymph was collected for three periods of 15 min. each before the administration of hyaluronid-

Table 1. Effect of Hyaluronidase on Arterial Blood Hæmatocrit and Total Plasma Protein

		Before	After hyaluronidase (min.)					P_{5-90} (per cent)
			5	15	30	60	90	
Arterial blood hæmatocrit (18 cases)	$\bar{x}$	42·5	46·5	46·7	46·7	47·1	46·4	< 5
	s	6·67	7·32	7·20	6·23	6·23	6·50	
Total plasma protein (10 cases)	$\bar{x}$	6·33	6·42	6·50	6·30	6·27	6·22	> 90
	s	0·69	0·50	0·49	0·61	0·62	0·69	

$\bar{x}$, mean; s, standard deviation.

Table 2. Effect of Hyaluronidase on Lymph Flow

	Controls mgm./min.	Time after hyaluronidase (min.)							
		0–15		15–30		30–60		60–90	
		mgm./min.	per cent*	mgm./min.	per cent*	mgm./min.	per cent*	mgm./min.	per cent*
Thoracic duct									
n	8	8	8	8	8	8	8	8	8
$\bar{x}$	463	1,113	+ 145	769	+ 70	589	+ 45	619	+ 53
s	330	764	88	564	56	413	65	446	58
P			< 0·1		~ 2		> 5		< 5
Liver lymph									
n	10	10	10	10	10	10	10	10	9
$\bar{x}$	87	161	+ 88	113	+ 35	86	− 2	88	+ 2
s	69	151	54	99	35	90	46	92	47
P			< 0·1		~ 1		> 70		> 20
Intestinal lymph									
n	11	11	11	11	11	11	11	11	11
$\bar{x}$	61	96	+ 63	79	+ 29	63	+ 10	62	+ 4
s	86	146	52	137	49	106	64	113	60
P			< 1		> 5		~ 60		~ 40

* Percentage increase in lymph flow.
n, Number of data available; $\bar{x}$ mean; s, standard deviation; P, percentage probability (Student's t test).

ase and afterwards for four further periods; the first two of 15 min., the others of 30 min. Lymph flow, the concentration of Evans blue in lymph and plasma, arterial blood hæmatocrit, and the concentration of total protein in plasma and lymph were determined before and after administration of hyaluronidase.

Hyaluronidase produced a small but significant rise of the arterial blood hæmatocrit in all experiments, but there was no significant change in total protein concentration of the plasma (Table 1).

Lymph flow increased in all vessels investigated. The most marked increase of flow-rate was recorded in the thoracic duct; there was also an increase of lymph flow from the liver and the intestines (Table 2). An analysis of the results showed that the increase of lymph flow was statistically significant if expressed as percentage of that before administration of hyaluronidase.

The disappearance of Evans blue from the circulation and the appearance of the dye in the lymph was enhanced by hyaluronidase. It has been shown that this dye is quite firmly bound to protein *in vitro*[6,7] and *in vivo*[8,9]. Therefore, we believe that the passage of dye from plasma to lymph marks that of the protein it labels. To confirm this assumption we investigated simultaneously the disappearance from the plasma and the equilibrium between plasma and lymph of Evans blue and dextran (mean molecular weight, 60,000) and also of human serum albumin labelled with iodine-131[4,5,10], and found a good agreement between the different substances. The disappearance of the labelled protein was estimated by the following equation[11]:

$$k = \frac{\ln (V_1C_1) - \ln (V_2C_2)}{T_2 - T_1}$$

where k is the fraction of dye (labelled protein) disappearing from plasma per min.; V_1 is the plasma volume before administration of hyaluronidase, V_2 the plasma volume 90 min. after administration of hyaluronidase, C_1 and C_2 the concentrations of dye in plasma and T_1 and T_2 the times of drawing the respective specimens of plasma. Hyaluronidase produced a definite increase in the amount of dye disappearing from plasma. In eighteen normal controls this was 0·00225 (standard deviation 0·000827); after hyaluronidase administration (in

Table 3. Effect of Hyaluronidase on Equilibration of Labelled Protein between Plasma and Lymph

Min.	Thoracic duct				Liver lymph				Intestinal lymph			
	0–15	15–30	30–60	60–90	0–15	15–30	30–60	60–90	0–15	15–30	30–60	60–90
Controls												
n	7	7	7	7	6	6	5	5	5	6	6	5
$\bar{x}$	15·4	35·1	43·6	60·1	16·0	34·5	45·4	60·0	7·8	28·8	54·5	59·2
s	8·3	26·6	25·9	35·2	11·4	15·6	14·3	10·0	3·9	12·4	24·5	27·2
Hyason												
n	8	8	8	8	9	9	9	8	8	8	8	8
$\bar{x}$	51·3	63·6	67·6	62·0	29·3	55·7	69·2	77·1	20·1	37·8	50·9	60·6
s	20·0	11·4	14·2	13·9	20·9	23·7	21·1	16·0	12·3	15·5	16·6	17·9
d*	3·63	2·63	2·18	0·13	2·58	2·09	2·50	2·37	2·62	1·20	0·31	0·10
P	<1	<5	>5	>90	≈5	>5	≈5	>5	<5	>20	>70	>90

* Behren's d test.
n, Number of cases; $\bar{x}$, mean of percentage relative concentration of dye in lymph and plasma; s, standard deviation; P, percentage probability.

Table 4. EFFECT OF HYALURONIDASE ON THE PROTEIN CONTENT OF LYMPH

		Before	Time after hyaluronidase (min.)				P*
			0–15	15–30	30–60	60–90	
Thoracic duct (7 cases)	$\bar{x}$	5·10	5·10	5·25	5·27	5·31	> 90
	s	0·92	0·86	0·83	0·73	0·95	
Hepatic lymph (8 cases)	$\bar{x}$	5·40	5·51	5·55	5·48	5·57	> 70
	s	1·11	0·83	0·79	0·76	0·94	
Intestinal lymph (7 cases)	$\bar{x}$	4·53	4·71	4·87	4·97	4·84	~ 20
	s	0·82	0·76	0·51	0·84	0·59	

$\bar{x}$, Mean; s, standard deviation.
* All values after administration of hyaluronidase pooled.

thirteen dogs) this rose to be 0·00333 (standard deviation 0·000655). The difference is highly significant ($P < 0·001$).

We also investigated the equilibrium of labelled protein between blood and lymph. As a convenient way of expressing the passage of labelled protein, the concentration of dye in the lymph was calculated as a percentage of the mean plasma concentration. Table 3 shows a significant increase of relative concentration in the lymph of all the vessels investigated. We were, however, unable to collect sufficient amounts of lymph for estimation of dye concentration in the cervical duct, but we gained the impression that cervical lymph also contains more dye after injection of hyaluronidase.

Finally, there was a small non-significant increase in the total protein concentration in the lymph (Table 4).

This evidence, in agreement with the findings of other workers, leaves no doubt that the permeability of the capillaries is increased by hyaluronidase. There is not only an increased leakage of dye, but after administration of hyaluronidase the transfer of labelled protein between plasma and lymph is also enhanced. Furthermore, there is a definite increase in lymph flow. All these findings point to an increased protein and fluid transfer from the capillaries to the extracellular fluid. The increase of capillary permeability is quite general and could be detected in all the areas studied. The effect of hyaluronidase is of short duration only.

It is interesting that there were no significant changes in the total protein content of the lymph. The maximum concentration of Evans blue in the lymph was identical in the dogs receiving hyaluronidase and in the untreated controls. Although, in the short experimental period, equilibrium between plasma and lymph was not attained, towards the end of this period there was no significant difference of relative dye concentrations between the controls and the treated animals. These results point to the further possibility that a moderate increase of capillary permeability—in spite of a marked protein leakage—does not necessarily increase the protein content of lymph, nor perhaps that of the tissue fluid. The protein leaving the capillaries, if it does not exceed a certain amount, can be cleared from the extracellular compartment by the increase of the lymph flow alone, without increasing the protein concentration in the lymph.

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GRAVIMORPHISM IN TREES

Effects of Gravity on Growth, Apical Dominance and Flowering in Fruit Trees

IT has long been claimed by horticulturalists that downward training of the branches of fruit trees reduces vegetative growth and promotes flowering[1–4]. These reports suggest that the position of the shoot in relation to the gravitational field may affect growth and flowering, but there appear to have been very few rigorous investigations of these effects in trees. A detailed investigation of the effects of gravity on growth, apical dominance and flowering in fruit trees was accordingly commenced in 1956.

The effect of the orientation of the shoot on its growth was investigated in apples, cherries, plums and blackcurrants, using 'maiden' trees planted in pots and restricted to a single shoot in the second year. The growth of trees maintained horizontally throughout the growing season was compared with that of the vertical controls for each species. The horizontal position was obtained by placing the whole plants and their pots horizontally. One group of horizontal plants was maintained with the same side of the plant uppermost throughout the period of treatment, while the plants of a second group were rotated through 180° twice each day. The treatments were commenced shortly before bud expansion in the spring. For watering, the horizontal plants were placed erect for 1–2 minutes, as required; to eliminate possible differential effects due to rain, the soil surface of the pots of the vertical series was covered with polyethylene sheeting. In order to maintain the experimental material as uniform as possible, all lateral shoots were removed as they emerged. In blackcurrant, there was a marked tendency for the outgrowth of laterals from the upper side of the stem, as has also been reported for citrus[5]. The extension growth was measured weekly throughout the growing season and the mean total extension-growth for the various experimental groups is given in Table 1.

In all species, the total growth of the horizontal trees was markedly less than that of the vertical controls, and the effect of the horizontal position was accentuated when the plants were rotated. In the cherries and plums the reduced total growth was due both to a smaller number of internodes and to reduced internode length, in the horizontal trees. In the apples and blackcurrants the difference in extension-growth was mainly due to differences in internode-length. Reduced hypocotyl extension in inverted seedlings of various species was reported by Hering[6].

Table 1. Effect of Shoot Position on Extension Growth

Species and treatment	No. of plants	Mean extension growth (cm.)	Mean inter-length (cm.)	Mean No. of inter-nodes
Cherry, Mazzard F12/1				
Horizontal, rotated	16	15·4 ± 1·4*	1·3	12
Horizontal, non-rotated	16	21·4 ± 1·7	1·5	14
Vertical	16	51·8 ± 2·1	2·5	21
Apple rootstock, No. 3436				
Horizontal, rotated	19	46·9 ± 1·5	1·4	32
Horizontal, non-rotated	19	52·9 ± 2·1	1·7	31
Vertical	19	69·3 ± 2·1	2·1	33

* Standard error.

A number of experiments has been conducted to investigate the interaction between apical dominance and the effects of gravity, and the results of two such experiments are given in Table 2. In these experiments, one-year stool-bed layers of apple rootstock *MM* 111 were pruned back to a height of 24 inches, and the subsequent growth was restricted to the laterals from the uppermost three buds. The resulting lateral shoots were trained as indicated.

From the results it is apparent that the growth of all shoots is less when they are in a horizontal position as compared with the vertical, but the uppermost shoots show a greater percentage reduction when trained horizontally than do the lower shoots (Experiment 1). As a result, there is relatively little difference in growth of the three shoots when they are all trained horizontally, so that only slight apical dominance is manifested. On the other hand, when all the shoots are trained vertically, the greater growth of the uppermost shoots results in well-marked apical dominance. Thus, it appears that the apical dominance exhibited by the uppermost shoot is only manifested when it occupies a vertical position. Since the lateral shoots usually grow out at an angle removed from the vertical, this will tend to reduce their growth further and to accentuate the apical dominance of the vertical leader.

The orientation of the shoot also has a marked effect on flower-initiation in apple rootstock No. 3436. None of the one-year maiden apple layers used in the experiment on extension-growth, described above, initiated flowers in 1956. The treatments were continued with the second year, however, and marked differences in flower-initiation were then observed. The 2-year-old layers grown in the normal vertical position initiated relatively few flowers, but the layers grown horizontally, both 'rotated' and 'non-rotated', showed heavy flowering on both 'spurs' of the 2-year shoots and also on the 1-year shoots

Table 2. Effect of Gravity on Apical Dominance

	Lateral No.	Shoot position*	No. of plants	Mean extension growth (cm.)
Exp. 1	1st	*V*	12	66·2 ± 2·6
	2nd	*V*		58·4 ± 3·4
	3rd	*V*		50·2 ± 3·1
	1st	*H*	12	42·4 ± 2·0
	2nd	*H*		40·6 ± 1·6
	3rd	*H*		39·6 ± 2·3
Exp. 2	1st	*V*	10	44·0 ± 2·0
	2nd	*V*		33·4 ± 3·4
	3rd	*V*		30·7 ± 1·5
	1st	*V*	8	49·2 ± 7·2
	2nd	*H*		26·8 ± 2·3
	3rd	*H*		27·3 ± 2·9

* *V*, vertical; *H*, horizontal.

Table 3. Effect of Gravity on Flowering

Species and treatment	No. of plants	No. of flowering buds	
		2-yr. shoots	1-yr. shoots
Apple rootstock No. 3436			
Horizontal, rotated	19	40	76
Horizontal, non-rotated	19	63	98
Vertical	19	1	4
Cherry, Mazzard F12/1			
Horizontal, rotated	16	1	0
Horizontal, non-rotated	16	19	0
Vertical	16	0	0

(Table 3). The vertical trees, instead of forming spur-shoots on the 2-year shoots, formed short lateral vegetative shoots. Thus, the orientation of the shoot in relation to gravity has a marked effect on flower-initiation in apple. Similar effects were observed also in cherries, although the number of flowering buds was much smaller than in apples (Table 3). Effects of gravity on flower-initiation have also been reported for pineapple[7] and soybeans[8].

These effects of gravity on growth and flowering are clearly related to geotropism. Since, however, the latter term is used to describe a growth curvature, it is not strictly appropriate for the phenomena reported here, for which it is proposed to introduce the term 'gravimorphism'.

The plant material for these investigations was supplied by East Malling Research Station, the assistance of which in this respect is gratefully acknowledged.

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Effect of Gravity on Flowering and Shoot Growth in Japanese Larch (*Larix leptolepis*, Murray)

Parallel with the investigation into the effects of gravity on growth and flowering of fruit trees[1], a series of experiments is also being carried out with forest trees. Species of *Pinus*, *Larix*, *Fagus* and *Betula* are being studied, but the present report deals chiefly with Japanese larch (*Larix leptolepis*, Murray).

While for fruit trees there is a certain amount of evidence from the experience of horticulturalists that gravitational effects may be of importance, there is little suggestion in the literature that this applies also to forest trees. However, Matthews and Mitchell[2], working on methods of training forest trees for heavy seed production, record that "nine-year-old Japanese and hybrid larch treated to form espaliers produced a great density of male and female flowers".

In order to investigate rigorously whether the actual position of the shoot relative to gravity influences the flowering of Japanese larch, an experiment was carried out in which branches were trained into horizontal and into downwardly directed positions, an equivalent branch in the same 'whorl' being

left in its natural upwardly curving ('upswept') position as a control. In some cases a further branch was fixed in its existing position to prevent any tendency to sag during the course of the experiment. The treatments were applied between the end of March and the end of April 1957 to 2–5-year-old branches on trees 10–12 years old which had not up to that time borne an appreciable number of flowers.

By autumn 1957 the flower buds for 1958 were clearly visible, and it was found that out of 12 treated trees 10 showed more flowering in horizontal and particularly in downwardly directed treatments than in the controls, the difference being very marked in 8 trees. As many as 200 flowers, mainly male but including some female, had been induced on some branches, compared with three or four flowers on the untreated branch. The remaining two trees did not flower at all, possibly because they were smaller than average. They are excluded from Table 1, as is one other tree which started flowering heavily in 1958 in any event.

Table 1. Effect of Gravity on Flowering in Japanese Larch

	Branch fixed in existing position	Control branch (unfixed)	Branch fixed in horizontal position	Branch fixed in downwardly directed position
Total number of flower buds	21	90	647	1,079
No. of branches involved	11	16	13	12
Average number of flower buds per branch	2	5·5	50	90

The flowering of young Japanese larch is thus markedly influenced by the position of the branches in relation to the gravitational field, the greater the branch angle (measured from vertically upwards) the heavier the flowering. In addition, the trees have been brought into heavy flowering at an age when they would normally bear few or no flowers.

It seems probable that this 'gravimorphic' effect is important also in the normal reproductive development of larch. It is well known that in trees of many species the vigorously growing young branches are upwardly directed, generally growing out at an angle which is characteristic of both the species and the individual tree. With increasing age, the branch angle usually becomes greater so that the branch often comes to assume a horizontal or even downswept position, no doubt partly or wholly due to its increasing weight. From the results of the foregoing experiment it seems clear that this natural change in branch angle will tend to favour the onset of the flowering phase in young trees. Further evidence in support of this view is seen in the fact that the unfixed control branches generally had appreciably more flowers than those branches which were fixed in their existing position at the beginning of the season. It was also noted that in trees with a naturally flatter type of branching, the unfixed controls generally bore more flowers than in trees where the branches were very upswept.

In addition to inducing flowering, the horizontal and downwardly directed training in the foregoing experiment markedly reduced extension growth during 1957. Table 2 gives the measurements for the leading shoots of the branches.

Similar marked reduction in extension growth was produced in birch (*Betula verrucosa*, Ehrh.) by pulling down individual branches.

Table 2. Effect of Gravity on Extension Growth in Japanese Larch
(Means of 11 branches)

	Control branch (unfixed)	Branch fixed in horizontal position	Branch fixed in downwardly directed position
Mean extension growth of main branch axis (cm.)	29·5 ± 2·3*	17·5 ± 1·5	14·0 ± 1·6
As a per cent of control branch	100	59·5	47·5

* Standard error of mean.

Gravity appears also to affect the distribution of flower buds on the individual larch twig. They may be seen to occur mainly on the lower sides of horizontally inclined twigs, and on all sides of the trailing twigs which are frequently found in this species. Now since the buds point forwards on the twigs at an angle of approximately 60–70° it would be expected that the flower buds on these horizontal and trailing twigs would point either downwards or horizontally, but not upwards. Quantitative verification of the observed distribution of flower buds can therefore be obtained by measuring the direction in which a large number of flower buds point in relation to gravity. Table 3 gives the results for two 5-year-old branches taken from trees which had recently commenced flowering.

Table 3. Distribution of Male Flower Buds in Relation to Gravity

Direction in which buds point	Angle (measured from vertically upwards)	Branch 1		Branch 2	
		No. of flower buds	Per cent	No. of flower buds	Per cent
Upwards	0° –22½°	—	—	—	—
¼ up	22½°–67½°	2	1	5	3
Horizontally	67½°–112½°	48	30	49	31
¼ down	112½°–157½°	77	47	82	52
Downwards	157½°–180°	36	22	23	14
		163	100	159	100

It is seen that an average of 98 per cent of the flower buds point either downwards or horizontally. Although this confirms the observation that there is a clear-cut zoning of the flower buds to loci in which they will point downwards or horizontally, it is not yet clear whether the response of the bud is directly determined by its own orientation in relation to gravity, or whether it is determined by the position of the twig or branch system on which it occurs.

In view of the generally accepted evidence that geotropic effects result from the differential distribution of growth-hormone in response to gravitational stimuli, a similar mechanism for these 'gravimorphic' effects may be expected. This problem is being investigated.

This work was carried out with the aid of a grant from H.M. Forestry Commission, which also kindly supplied the trees for the experiments. Acknowledgments are especially due to Mr. J. D. Matthews of the Forest Genetics Section, who has been closely associated with this project.

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LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications.

Polar Wandering, a Random Walk Problem

IT has often been supposed that due to redistributions of mass the body of the Earth as a whole has shifted relative to its rotational axis, which has remained fixed relative to the Sun. It is convenient to think of this as movement of the pole over the surface of a fixed Earth. Since the Proterozoic the pole appears to have been displaced by as much as 90° of arc to its present position. Orogenic or epeirogenic movements and ice-cap melting or formation with the attendant fluctuations in sea-level are usually cited as possible causes of polar wandering. Darwin[1] and Kelvin[2] first discussed the dynamic stability of the Earth. Gold[3] and Munk[4] have recently re-examined the problem and have concluded that such large displacements of the pole could be a consequence of such geological activities.

The position of the pole may be obtained from the average direction of remanent magnetization of rock formations when the hypothesis[5] is made that the Earth's magnetic field, when averaged over a few thousand years, has approximated to a geocentric axial dipole. It has been customary to connect these pole positions[6] by curves passing from the Pacific Ocean along the east coast of Asia to the position of the present pole. But since the geological events which may have been responsible for polar wandering have been irregular, both in their type and in their distribution and timing, they are likely to have produced random polar movements. In this communication an attempt is made to fit the palæomagnetic data to a random walk of the pole over the Earth's surface.

If the sampling area has undergone continental drift, the polar wandering rate would have the drift velocity superimposed upon it, and both would be present in the palæomagnetic data. In this work the pole paths relative to Europe and North America have been used because their similarity in shape and direction suggests that neither continent has been displaced in latitude relative to the other to any great extent, but it has to be borne in mind that errors may arise from this source. The simplest case of a random walk is that on a plane, and provided the individual displacements are small and the total displacement does not greatly exceed 90° of arc it is not essentially different from a random walk on a sphere.

The probability density $w(\psi)$ that the pole will have an angular displacement ψ from the present pole at a time t is given by:

$$w(\psi) = \frac{2\psi}{C^2kt} \exp\left(-\frac{\psi^2}{C^2kt}\right) \quad (1)$$

where C^2 is the mean square of the individual steps in the walk and k is the number of steps per unit time. The mean value of the angular displacement at time t is given by:

$$\int_0^\infty \psi\, w(\psi)\, d\psi \quad (2)$$

$$= \int_0^\infty \frac{2\psi^2}{C^2kt} \exp\left(-\frac{\psi^2}{C^2kt}\right) d\psi \quad (3)$$

$$= \tfrac{1}{2}\pi^{1/2}\, C(kt)^{1/2} \quad (4)$$

and the mean value of the square of the displacement is C^2kt. Thus ψ is expected to vary linearly with $(kt)^{1/2}$ and points, the co-ordinates of which are $(\psi, t^{1/2})$, will be scattered along the line $\psi = C(kt)^{1/2}$. The limits for ψ at a probability of 0·95 are:

$$\psi_u = \varepsilon_u C(kt)^{1/2} \quad (5a)$$

$$\psi_e = \varepsilon_e C(kt)^{1/2} \quad (5b)$$

where the factors ε_u and ε_e are given by:

$$0{\cdot}025 = \exp(-\varepsilon_u^2)$$

and

$$0{\cdot}975 = \exp(-\varepsilon_e^2)$$

respectively. Thus ψ lies between the limits $1{\cdot}92\ C(kt)^{1/2}$ and $0{\cdot}16\ C(kt)^{1/2}$ at $P = 0{\cdot}95$.

In Fig. 1 the displacements are plotted against the square root of time, the results from Western Europe and North America being indicated by full and open circles, respectively. The straight line through the origin which best fits these data by least squares is given by

$$\psi = 3{\cdot}0\, t^{1/2} \quad (6)$$

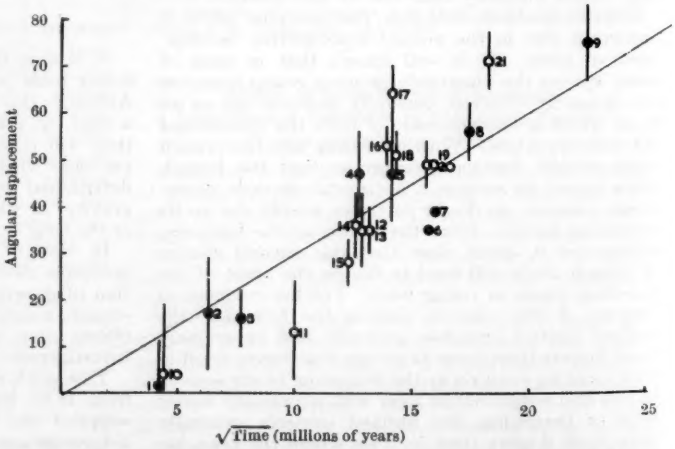

Fig. 1. The angular displacement of the pole from its present-day position is plotted against the square root of time in millions of years. The pole positions used are numbered as follows: 1, Miocene lava, France; 2, Oligocene intrusives, France; 3, Eocene lavas, Northern Ireland; 4, Triassic marls, England; 5, Permian traps, Exeter; 6, Carboniferous millstones, Derbyshire; 7, Carboniferous toadstones, Derbyshire; 8, Devonian sandstones, Wales; 9, Cambrian sandstones, Wales; 10, Upper Tertiary lavas, Washington; 11, Cretaceous sandstones, Colorado plateau; 12, Triassic sandstones, Springdale; 13, Triassic lavas, Holyoke; 14, Triassic lavas, sediments, Connecticut; 15, Triassic sequence, New Jersey; 16–18, Permian Supai beds, Arizona; 19, Carboniferous sandstones, Arizona; 20, Carboniferous concretion, Texas; 21, Silurian sediments, Maryland. The vertical lines through the pole positions represent the error (at $P = 0{\cdot}05$) in determining the latitude. The European and North American results are indicated by full and open circles respectively

where ψ is in degrees of arc and t is in millions of years. The expected value of 3° of arc for the magnitude of the displacement of the pole in one million years is a useful quantitative value for other workers interested in the mechanism of polar wander.

It is emphasized that since the movement of the pole may be considered to be a random walk, there will be, on one hand, periods during which there is effectively very little displacement of the pole (for example, the Quaternary) and, on the other hand, periods during which rapid displacement of the pole is in evidence (for example, Carboniferous[7]).

This work was carried out while I was a research student in the Department of Geophysics of the Australian National University at Canberra, A.C.T. I wish to thank my supervisors, Prof. J. C. Jaeger and Mr. E. Irving, for their criticism and helpful discussion.

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Secular Variation in the Direction of Geomagnetism as the Standard Scale for Geomagnetochronology in Japan

It is well known that igneous rocks and ceramic objects are permanently magnetized in the direction of the Earth's magnetic field in which they were cooled from a high temperature. I have already pointed out that the baked earth in the hearths of prehistoric dwelling pits would be magnetized similarly, and that this could be applied to developing chronology for anthropology and archæology[1]. The term 'geomagnetochronology' may be defined as chronology from palæomagnetism.

In Japan three kinds of sources—hearths, furnaces and kilns—offer baked earth of various ages. A hearth is a simple fireplace made directly on the floor of a prehistoric dwelling pit, a furnace is a structure built up with sandy clay against the wall of a dwelling pit of the protohistoric and the historic ages, while a kiln is an ascending tunnel-like structure built with clay on the slope of a hill, in which ceramic wares were baked in historic times.

Samples of small blocks of baked earth, generally about ten in number, were collected from each fireplace and the remanent magnetism was measured with an astatic magnetometer. The mean direction of the remanent magnetism of each set was calculated by Fisher's method[2], and for comparison the data from samples from sites far from Tokyo were reduced to Tokyo by Nagata's procedure[3].

The samples can then be dated by comparing the direction of the remanent magnetism with a standard scale of the secular variation in the direction of geomagnetism in the past; thus it is essential to establish such a standard scale. This standard scale has been set up for the past 1,700 years and it is shown in Fig. 1. Encircled points indicate the geomagnetic inclination and the geomagnetic declination at known dates, most of which were reported or cited by Nagata and Kato[4]. Old records of geomagnetic observations gave the points 1613, 1694, 1802, 1827, 1854, 1860, 1887, and the curves from 1887 to the present, while measurements of the remanent magnetism of lava-flows dated by the descriptions of volcanic eruptions of 864, 1471, 1749, 1778 and 1779 in old documents gave the other encircled points. Besides these, points 1 and 2 represent the direction measured by me for samples of baked earth from two kilns, the dates of which are almost certainly known from the type of pottery as about 1300. These gave the curve of inclination for the period from 864 to the present shown in Fig. 1; the curve was then extrapolated for the time before 864 on the assumption that the inclination underwent a secular variation similar to that estimated for the period after 864. On this curve were plotted the inclinations obtained from sixty-five sets of samples of baked earth from hearths, furnaces and kilns of various ages; eighteen of these are shown as points 3–20. The declinations associated with these inclinations were then plotted, and the secular variation curve of declination shown in Fig. 1 was drawn so as to fit as many as possible of the points. The vertical lines at each point indicate the magnitude of the Fisher radius of the circle of confidence at the 5 per cent level.

Three sets of samples which yielded points well off the curves have been ignored for the present. The two curves thus obtained seem to be reasonably accurate, since almost all the points are in general

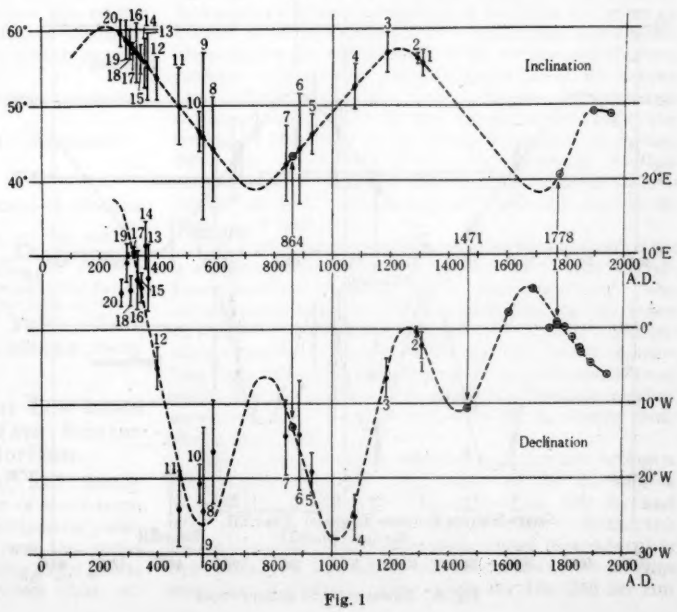

Fig. 1

Table 1

No. of samples	Declination D	Inclination I	Fisher's θ for $P = 0{\cdot}05$	Radiocarbon date
12	5·1° E.	49·2°	3·3°	4,546±220 B.P.
14	3·7° E.	50·6°	1·2°	
15	5·6° W.	48·2°	2·9°	5,100±400 B.P.
20	6·1° W.	48·9°	3·2°	

chronologically consistent with archæological evidence.

Although we have no specimens from before 864 which can be dated from records, radiocarbon assay can be used instead. At present two such assays are available for prehistoric Japan. One is that made by Libby, of the University of Chicago, on charcoal found on the floor of a dwelling pit at the shell-mound of Ubayama in the Chiba Prefecture[5]. I collected samples of baked earth from the floor of this dwelling pit and measured their remanent magnetism. The other radiocarbon date was obtained by Crane, of the University of Michigan, from a canoe excavated from a peat formation at Kamo in the Chiba Prefecture[6]. In this case there was no baked earth at the site, but I used samples from hearths of three dwelling pits which contained the same type of pottery as that associated with the canoe. These were at the shell-mound of Minamihori in the Kanagawa Prefecture. The results are presented in Table 1.

In 114 sets of samples of various ages during the past 6,000 years or so, the direction of remanent magnetism generally fell within the range 40–60° for the inclination, and 20° E.–30° W. for the declination. This suggests that the secular variation in the direction of geomagnetism for the past 6,000 years is similar to that estimated for the past 1,700 years. Assuming this, the most probable secular variation curves of the direction of geomagnetism for a time range covering 4,546 and 5,100 years before the present were tentatively drawn as in Fig. 2. On these curves the results of twenty-four measurements on baked earth from hearths fell in positions consistent with the chronological order known from the types of pottery associated with them. One result, however, was well off the curve.

A detailed account of this work will be published in *Journal of the Faculty of Science*, University of Tokyo.

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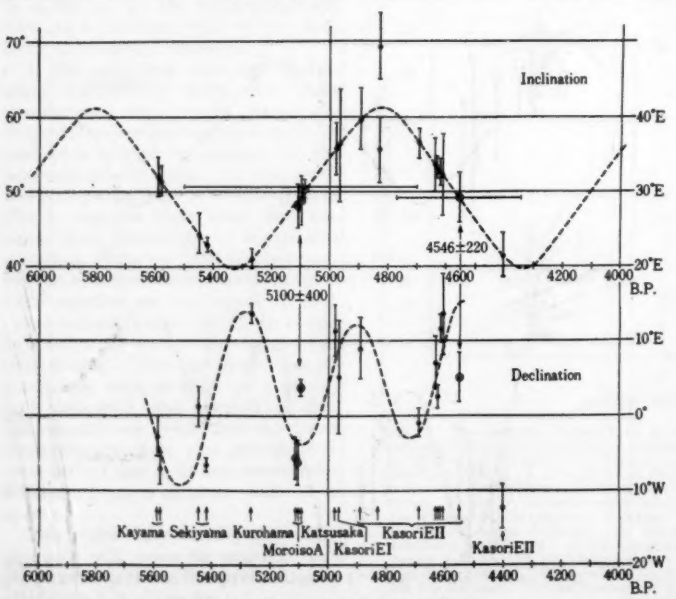

Fig. 2. Names refer to pottery types

Measurement of the Thickness of the Earth's Crust in the Albertan Plains of Western Canada

As a contribution to the International Geophysical Year, a group composed of Canadian, American and British oil interests and independent geophysical contractors has recently carried out a large-scale seismic refraction experiment in order to measure the thickness of the Earth's crust, or depth to the Mohorovičić discontinuity, in the Albertan Plains of western Canada.

Fifteen seismic parties using refraction equipment were spaced at roughly uniform intervals over a distance of 130 km. and two-way observations were made from 900-lb. buried charges of dynamite located at the extremities of this range. The line extended approximately parallel to the frontal thrust of the Rocky Mountains, between latitudes 50° 45′ N. and 51° 47′ N., and some 100 km. to the east of the thrust.

For the upper crustal material recorded as first events in both directions of shooting, the velocities were about 3·5 and 6·0 km./sec. The first represents Cretaceous shales and sands to a depth of 2·3 km. The second velocity represents the known Palæozoic limestones, and its event carried for the whole length of the line.

A later event with the characteristic time-distance relation of a reflexion shows a marked increase in energy content at a distance not less than about 100 km. where its velocity is about 8·2 km./sec. This event has been ascribed to reflexions from the Mohorovičić discontinuity amplified by refractions from beyond the critical angle, and the time distance variation of this event is almost identical in both directions of shooting, thus indicating an absence of dip.

Using the above velocities, the depth to the Mohorovičić discon-

tinuity is computed to be about 36 km. However, the velocity of 6 km./sec. is not necessarily representative of the whole of the crustal material from the Palæozoic to the Mohorovičić discontinuity, and one would be justified in assigning a somewhat greater velocity than this in the depth calculation and thereby derive a greater depth. Taking a value of 6·3 km./sec. as an average of all published velocities for the crust under North America, the depth to the Mohorovičić discontinuity becomes about 40 km. Furthermore, other distinct events with a velocity of about 7·2 km./sec. have been recorded, and if these are associated with refractions from the lower part of the crust, the depth to the Mohorovičić discontinuity must be increased on this account. A re-computation, including the data from these events and adhering to the velocity of 6·0 km./sec. for the upper layer, yields a total depth to the Mohorovičić discontinuity of 47 km.

The range of depths thus indicated (40–47 km.), suggests that the crust in the western Albertan plains is thicker than the 30–35 km. that has been generally observed in plains areas elsewhere in the world[1]. It appears that crustal thickening that could be expected under the Rocky Mountains extends east of the mountain front at least by 100 km.

The 7·2 km./sec. layer which is inferred to lie at a depth of about 25 km. may be comparable with a 7·0 km./sec. zone observed at the same depth by Hodgson[2] in eastern Canada, and a 7·2–7·4 km./sec. layer noted at 20 km. in California and Nevada by Press[3]. The relatively weak waves refracted from this interface were observed as second events on our records. It is not likely that they could have been identified without multi-trace recording equipment of the type used in seismic prospecting which has been put to good account in the U.S.S.R.[4]. These observations and others recently reported from Europe tend to support the existence of the discontinuity first inferred by Conrad[5] and believed by some seismologists to represent an interface between 'granitic' and 'gabbro' layers within the crust.

It will be interesting to see how this result co-ordinates with the seismic measurements made at the time of the Ripple Rock explosion, since one of the observation stations recording this explosion coincided with one of the shot points in the refraction experiment.

A fuller account of this experiment will be published at a later date.

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Alberta, Canada. May 30.

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Influence of the Semi-Permanent Low-Level Ocean Duct on Centimetre Wave Scatter Propagation beyond the Horizon

Since 1949, the Admiralty Signal and Radar Establishment has conducted a number of short-term investigations on the propagation of centimetric radio waves over sea, at ranges well beyond the radio horizon. Some details of this work have been given recently by Joy[1,2]. It has been shown that, at

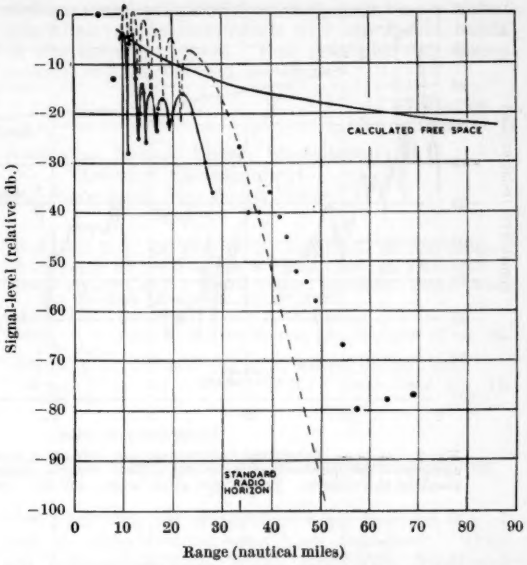

Fig. 1. – – – –, Theoretical interference and diffraction curve for standard atmosphere. Transmitter aerial height, 60 ft.; receiver aerial height, 400 ft.

frequencies of about 10,000 Mc./s., the extra-diffraction signal-levels relative to free space are invariably some 10–15 db. lower than the corresponding levels at 3,000 Mc./s. at all ranges beyond the radio horizon. However, the signal attenuation-rate with distance is very similar at these two frequencies. The observed difference in signal-level is apparently inconsistent with available theories[3,4] of radio wave scattering in the troposphere, and Starkey *et al.*[5] have suggested that it provides support for the alternative theory of layer reflexions from refractive index discontinuities in the lower atmosphere.

A significant feature of this Establishment's measurements of signal strength as a function of range at 10,000 Mc./s. over sea paths is that there is a similar degradation in the overall level of the interference pattern relative to the free-space level at ranges approaching that of the radio horizon. Examples of measurements made in the North Sea during the spring of 1956 and in the English Channel in spring 1957 are given by Joy[2]. Examples of further measurements made in the English Channel in the winter of 1957 and spring of 1958 are shown in Figs. 1, 2 and 3.

Fig. 1 shows the interference pattern obtained with a shipborne transmitter aerial at 60 ft. and a land-based receiver aerial at 400 ft. above sea-level. The interference maxima which correspond to the lobes in the vertical coverage diagram at elevations greater than about 0·4° relative to the Earth tangent (ranges less than 12 nautical miles) attain the free-space level while the maxima corresponding to lobes at smaller elevations are depressed by about 12 db. below their theoretical levels.

Figs. 2 and 3 show measurements made using a land-based receiving equipment at 50 ft. and a 10,000 Mc./s. airborne transmitter at 100 ft. and 250 ft. above sea-level respectively. With the transmitter at 100 ft. the theoretical signal-level is approached at elevations exceeding about 1° (ranges less than 1 nautical mile) while for the 250 ft. run

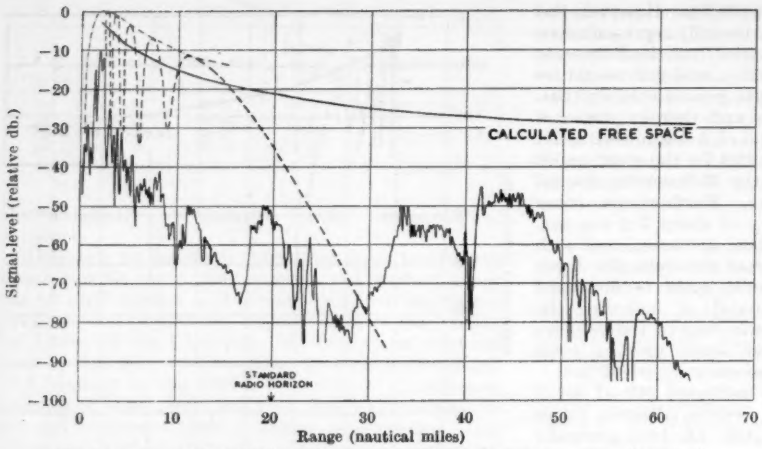

Fig. 2. — — —, Theoretical interference and diffraction curve; ——·——, theoretical envelope of interference maxima taking account of aerial vertical polar diagrams (all for standard atmosphere). Transmitter aerial height, 100 ft.; receiver aerial height, 50 ft.

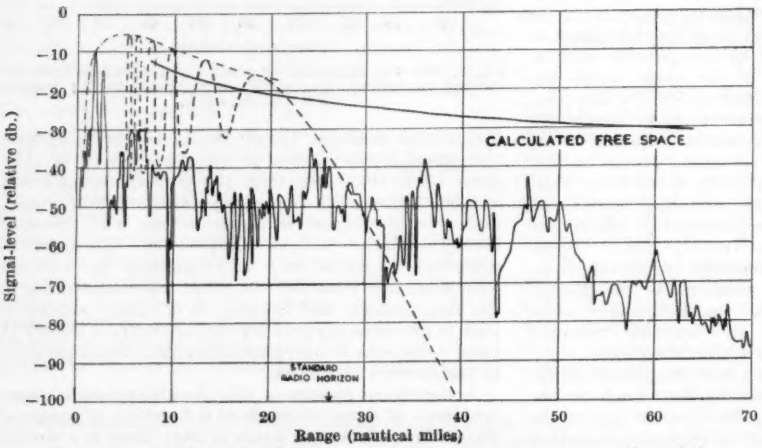

Fig. 3. — — —, Theoretical interference and diffraction curve; ——·——, theoretical envelope of interference maxima taking account of aerial vertical polar diagrams (all for standard atmosphere). Transmitter aerial height, 250 ft.; receiver aerial height, 50 ft.

the elevation also exceeds about 1° (ranges less than 2 nautical miles).

The distortion of the vertical coverage diagram at low elevations results from the diversion of almost horizontally directed energy by the semi-permanent low-level ocean duct[6]. The energy diverted from the lowest lobes is guided near the surface of the sea well beyond the horizon. With receiving aerials sited relatively high, the surface-guided component of the signal beyond the horizon is not directly observable (Fig. 1). However, with relatively low receiving aerials, the surface-guided energy is clearly apparent (Figs. 2 and 3). Day-to-day variations in the observed signal are experienced as the magnitude and intensity of the duct change.

Since only the low-level lobes contribute to radio wave scattering in the lower troposphere, it follows that any diversion of energy from these lobes will result in correspondingly less power entering the volume common to the transmitter and receiver aerial beams and being scattered in the receiver direction. It follows, therefore, as suggested by Richards[7], that for purposes of applying a scattering theory to the extra-diffraction signal at 10,000 Mc./s. the measured free-space level of the contributing lobes should be used instead of the theoretical value. When this is done there is no longer any marked discrepancy in signal-level at long ranges between 3,000 and 10,000 Mc./s. observations. Since the energy diverted from the lowest lobes at 10,000 Mc./s. reappears as an enhanced surface-guided component it follows that, at ranges well beyond the radio horizon, a high-sited receiving aerial will detect only a degraded scatter signal component, while a low-sited receiving aerial may detect a composite signal consisting of the degraded scatter component plus the surface-guided component. The relative contributions of the incoherent and coherent components in the latter case will vary with short-term variations in the magnitude and intensity of the low-level duct, while the median level of the total signal remains substantially unchanged. Such behaviour has in fact been observed[2].

The normally experienced characteristics of the low-level duct do not permit regular support of a surface-guided component over sea at 3,000 Mc./s. In fact, the extra-diffraction signal fields observed over the sea are in good agreement with the theoretical predictions of scatter theory. The present work makes it clear that the scatter mechanism itself is equally effective at 10,000 Mc./s., but that additional factors are involved in propagation over the sea beyond the horizon which may limit its effective exploitation.

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Determination of Traces of Oxygen in Sodium Metal by Infra-red Spectrophotometry

THE principal methods for the determination of traces of oxygen in sodium metal are based on the titration of sodium monoxide after the metal has been amalgamated and the oxide filtered off[1,2]; distilled in vacuum[3,4]; or allowed to react with an alkyl halide[5]. A 2 gm. sample of sodium metal containing 50 p.p.m. oxygen contains $1{\cdot}25 \times 10^{-5}$ equivalents of sodium monoxide. In the alkyl halide method, the presence of a 7×10^3 fold quantity of sodium bromide introduces difficulties in the determination of sodium monoxide by conventional volumetric methods. Elsewhere this difficulty has been discussed and a solution suggested[6]. The amalgam and distillation methods also suffer from some disadvantages associated with quantitative separation and subsequent estimation of the oxide.

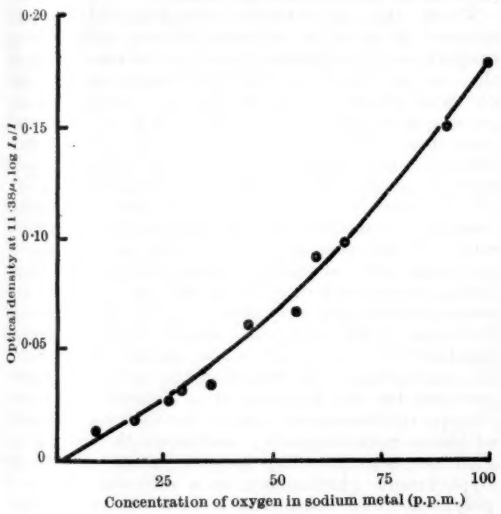

Fig. 1. Oxygen content of sodium metal by infra-red spectrophotometry

The use of an infra-red pressed-disk technique[7] with the alkyl halide method obviates difficulties associated with determinations of sodium monoxide in the range 5–100 p.p.m. in sodium metal. Following the reaction of the sodium metal with the alkyl bromide[5], the reaction mixture is dissolved in water and the unchanged oxide (now hydroxide) is converted into sodium bicarbonate by passing in excess carbon dioxide. The solution is then freeze-dried and the resultant powder heated at 400° C. for 2 hr. 1,500 mgm. of the sodium bromide–sodium carbonate mixture is then compressed to a clear disk by the usual technique[7]. Infra-red spectrophotometric analysis, using a Perkin Elmer model 21 infra-red spectrophotometer, shows absorption bands at 4·00, 6·93, 11·38 and 14·19μ. The absorbance at 11·38μ due to sodium carbonate is not subject to any interference, and although Lambert's law is not obeyed, from a standard curve (Fig. 1) the oxygen concentration in the original metal can be estimated with an accuracy of approximately 10 p.p.m. by weight.

The infra-red procedure also opens the way for the simultaneous determination of other impurities in sodium metal provided that they may be converted quantitatively to compounds with absorption bands in the infra-red region. Full details of the above method will be reported elsewhere.

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A New Configuration of Deoxyribonucleic Acid

STRUCTURES for deoxyribonucleic acid in the *A* and *B* configurations have been described[1]. They are compatible with X-ray diffraction data and embody the base-pairing hypothesis suggested by Watson and Crick[2]. The results we describe here strengthen our belief that no alternative stereochemical hypotheses could be used to build models in agreement with the data.

We have observed a reversible transition between the *B* X-ray diffraction pattern of the lithium salt of deoxyribonucleic acid and a similar but distinct pattern we call *C* (Fig. 1). The transition from *B* to *C* is induced by lowering the relative humidity from 66 to 44 per cent. By slight alteration of the *B* model we have arrived at a model for *C* and accounted for the main differences between *B* and *C* diffraction patterns. The base pairs were moved by about 2 A. away from the helix axis, and tilted by about 5°; the pitch of the helix was altered so that there were 9·3 instead of 10 base pairs per turn.

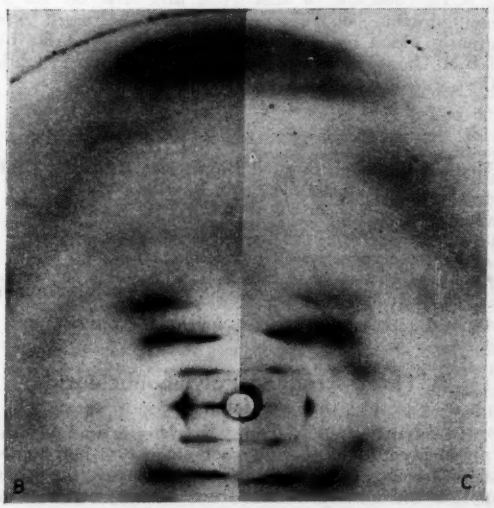

Fig. 1. Diffraction pattern of lithium salt of deoxyribonucleic acid in the *B* (left) and *C* (right) configuration

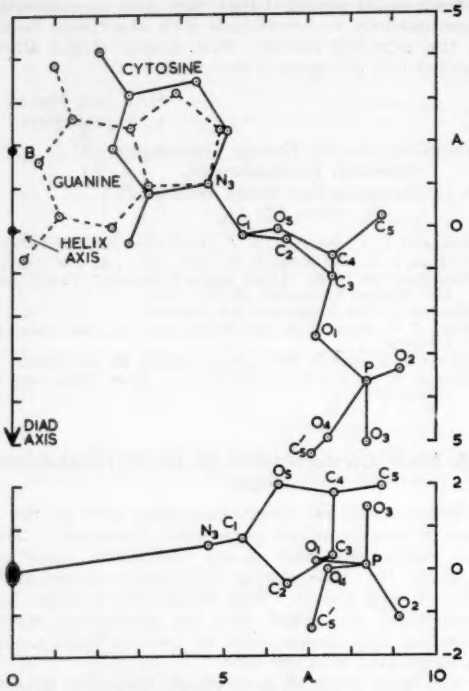

Fig. 2. A preliminary model of the *C* configuration of deoxyribonucleic acid showing approximate projection of a nucleotide on planes perpendicular to the helix and diad axes. *B* is the helix axis in the *B* configuration

In building a molecular model of deoxyribonucleic acid, there is considerable stereochemical freedom in arranging the components and there is, therefore, a small possibility that for any single configuration the agreement between observed and calculated diffraction might be fortuitous. This possibility now seems much smaller, because of our ability to follow the transition between two closely related configurations.

A full account of this work and that on the *B* configuration is being prepared. The work was greatly aided by computer time made available by I.B.M. United Kingdom, Ltd., and I.B.M. World Trade Corporation.

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A Three-stranded Polyribonucleotide Structure

The synthetic polymers, polyadenylic acid (*A*) and polyuridylic acid (*U*) interact strongly when mixed together in aqueous solution. Evidence for interaction on mixing comes from many observations, including increases in viscosity, sedimentation coefficient and molecular weight and decrease in ultraviolet absorption[1]. The last phenomenon, referred to as a hypochromic effect, is observed in the reverse fashion for deoxyribonucleic acid (P. Doty, private communication), that is, on thermal disruption of the double chain helical molecule in solution there is a substantial increase (about 30 per cent) in the optical density. This parallel behaviour of deoxyribonucleic acid and the chemically related synthetic complex suggests that their structures may be comparable. Added weight to this view is given by X-ray diffraction pictures[2] which show remarkable similarities between naturally occurring deoxyribonucleic acid and a synthetic fibre of polyadenylic acid/polyuridylic acid (*AU*) drawn from a solution containing equimolar portions of polyadenylic and polyuridylic acids. These facts have led Rich[3] to propose that the hydrogen bonding in the polyadenylic acid/polyuridylic acid complex is of the same type as that observed between adenine and thymine in deoxyribonucleic acid.

When the polyadenylic acid/polyuridylic acid complex is mixed in aqueous solution with varying proportions of polyuridylic acid, a maximum drop in the optical density is observed (under appropriate chemical conditions) when the two compounds are present in equimolar amounts[3]. Rich has suggested that this is due to the formation of a three-chain structure, containing one chain of polyadenylic acid and two of polyuridylic acid, and designated *AUU*. Furthermore it has been proposed that the original complex maintains its deoxyribonucleic acid-like structure and that the second chain of polyuridylic acid winds around the first two so as to form a triple helix. In such a structure the only way in which the second polyuridylic acid chain could form two strong hydrogen bonds with the complex is by hydrogen bonding from its O_6 and N_1 to the adenine N_{10} and N_1 respectively. Disregarding the details of Rich's proposal for the moment, it is difficult to explain the spectrophotometric data other than by some sort of three-chain structure; confidence in this type of structure is increased by the observation[4] of a similar hypochromic phenomenon in a different system of polynucleotides containing a 1 : 2 mixture of polyadenylic and polyinosinic acids (*AII*). Unfortunately X-ray diffraction pictures of these three-stranded complexes are not available and, consequently, it is difficult to evaluate molecular models. Aside from purely stereochemical considerations, however, there is new chemical evidence that may be important in judging possible three-chain structures, and I wish to propose a new structure of *AUU* to which I have been led by chemistry rather than by X-ray diffraction.

The chemical evidence on which this new structure is based relates to Rich's observation[3] that the divalent cation, Mg^{++} or Mn^{++}, not only accelerates the reaction $AU + U \rightarrow AUU$ but that it also complexes to the extent of one or two ions per three nucleotides. The problem of binding to nucleic acid by magnesium ions has been studied and reported elsewhere[5,6], and the conclusion was reached that under appropriate conditions the ions[6] will react strongly with deoxyribonucleic acid at sites on the purines which contain configurations favourable for chelation. In particular, adenine in nucleic acid can chelate magnesium ions between the N_7 and N_{10} positions of the purine, ring, but only when the plane containing the N_{10} amino-group is turned out of the plane of the purine, because of the steric interference to chelation offered by the amino hydrogens. (It is

possible that the amino hydrogens prefer to remain in the plane of the adenine because of the partial double bond character of the C_6—N_{10} bond. In adenine hydrochloride the C_6—N_{10} bond has a length[7] of 1·27 A., corresponding to more than 50 per cent double-bond character. Unfortunately, adenine is not directly comparable with its hydrochloride, since the formation of a resonant hybrid with a C_6—N_{10} double bond involves a separation of charge in the former. Thus one would expect the C_6—N_{10} to have more double-bond character in the hydrochloride. It seems clear that there will be some shortening of the C_6—N_{10} in adenine over the single bond-length, but in view of our ignorance as to its exact amount it is most difficult to say how much stabilization energy will result from this partial double-bond character.) Applying this information to the *AUU* system we see that here there is one purine per three nucleotides and therefore one site per three nucleotides for strongly binding the magnesium ion. The binding of magnesium ions by adenine in *AUU* necessitates the destruction of one of the original hydrogen bonds between the polyadenylic acid/polyuridylic acid double helix because of the required rotation of the N_{10} amino-group. Moreover, it will not be possible to make the hydrogen bonds between the second polyuridylic acid chain and the adenine suggested by Rich because the appropriate binding site on adenine is already occupied by the magnesium ion.

These considerations have led to the investigation of possible alternative structures for *AUU*, which have two strong hydrogen bonds per nucleotide and, furthermore, can accommodate the magnesium ion in the chelating position on adenine. In so doing it has been found that there is only one way of combining the three nucleotides which is sterically feasible. The scheme of hydrogen bonding involves a complicated system of tilts of the planes of the bases and is shown in projection in Fig. 1 for a nucleotide triplet. The hydrogen bond distances, N—H . . . *X*, are given in the figure and in all cases the deviation of N—H . . . *X* from linearity is less than 20°.

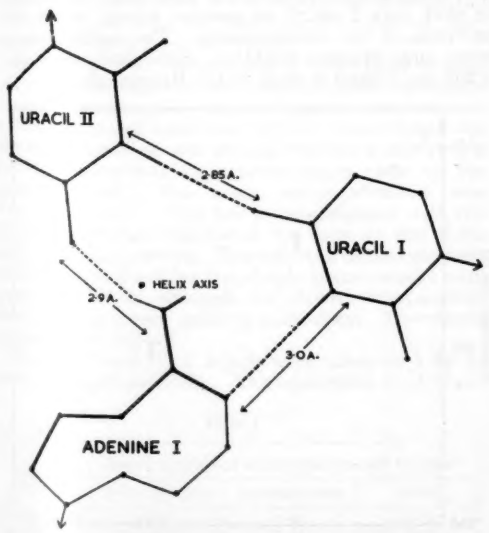

Fig. 1. Base pairing in three-stranded structure. The plane of adenine I is tilted about 44° relative to uracil I and about 37° relative to uracil II

Based on this system of nucleotide hydrogen bonding, a three-chain right-handed helical structure has been built. This model has a unit translation along the helical axis of 4·2 A. and a twist of 36° per triplet to give an exact repeat every thirty nucleotide residues or every ten residues along one chain. The sequence of atoms in the phosphate sugar backbone, which has an average diameter of 19 A., runs in the same direction in all three chains. Adenine I and uracil I (see Fig. 1) are related by a diad axis and as a result the backbone in the two polyuridylic acid chains runs in the same sense relative to the base groups as it does in deoxyribonucleic acid; but the sense in the polyadenylic acid chain is opposite to that in deoxyribonucleic acid. The planes of the two uracil bases are tilted only a few degrees from the perpendicular to the helix axis, whereas the plane of the adenine is tilted about 40°. The bond distances have been determined to an accuracy of ± 0·15 A. and the bond angles are the same within ± 3° as those in the deoxyribonucleic acid *B* structure[8]. The OH on the C_2 of the ribose has no short contacts in this model except those inherent in the ribose ring. The shortest contact (2·9 A.) observed is that between the ring oxygen of the sugar and the C_4 position on the uracils. However, this could probably be increased by further adjustment. Since so few short van der Waals contacts exist it would appear that a structure of this type is possible; but it should be emphasized that the dimensions of this model are arbitrary except for the specification of the hydrogen bonding between the nucleotides.

Although the *AII* polymer (mentioned earlier as showing the same hypochromic behaviour as *AUU*) has not been closely examined with models, the same type of hydrogen bonding appears to be possible.

It is interesting that the three-stranded structure for *AUU* proposed here involves molecular rearrangement in the original polyadenylic acid/polyuridylic acid complex prior to the attachment of a second chain of polyuridylic acid. The fact that the *AUU* complex does not form instantaneously in solution from a mixture of polyadenylic acid/polyuridylic acid +polyuridylic acid even under the most favourable conditions[3] must be due to the relatively high energy of the activated complex for its formation. The activated complex most likely involves a strained hydrogen bond between the adenine N_{10} and the uracil O_6 which is on the verge of breaking. It is easy to see that magnesium ions could lower the energy of the activated complex through the formation of a chelate with adenine. This lowering of the activation energy by magnesium ions would account for the fact that the *AUU* complex, although stable in media of high ionic strength lacking divalent cations, nevertheless forms much more rapidly in their presence.

The problem of deoxyribonucleic acid acting as a template for ribonucleic acid formation may be related to the structure of three-chain complexes of the type discussed here, and a specific coding mechanism, involving a three-chain complex as the template mechanism for making nucleic acids, has been proposed[9].

I would like to thank my colleagues at this laboratory for the use of molecular models and for advice and criticism, and also Prof. P. Doty for discussions on the solution chemistry of polynucleotides.

Note added in proof. X-ray pictures, on material containing a 1 : 2 molar ratio of polyadenylic and polyuridylic acids obtained in this laboratory on material given by R. F. Beers and R. F. Steiner, suggest modifications in the model described here. The X-ray pictures suggest that the unit translation along the helical axis be changed from 4·2 A. to 3·86 A. and the twist of 36° per triplet be changed to about 41°. In view of these results and the desirability of obtaining van der Waals contacts between the planes of the base groups, it now seems more reasonable to tilt both adenine I and uracil II about equal amounts (20°) and in the direction of the pitch of the helix. These preliminary results from X-ray diffraction necessitate more detailed consideration which will be presented elsewhere. However, it does not appear that there is any inconsistency with the chemical arguments presented here concerning the hydrogen bonding.

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Vibrational Frequency associated with the Boron–Nitrogen Dative Bond in Amine Boranes

Research in the chemistry of boron has been extremely active in the past few years and its Lewis acid-base complexes have been of particular interest. Although the boron–nitrogen dative bond is one of the most stable of such bonds to boron and occurs in a number of important boron compounds, the vibrational stretching frequency of this bond in the rather few cases studied has been assigned an unexpectedly high value. For example, in complexes of boron trifluoride with ammonia[1] and nitrogen heterocycles[2], frequencies lying in the range between 980 cm.$^{-1}$ and 1,120 cm.$^{-1}$ have been assigned to this motion, in the complex of boron trimethyl with ammonia, a value of 1,105 cm.$^{-1}$ has been selected[3], and in the complex of borane (BH_3) with nitrogen trimethyl ($N(CH_3)_3$) a value of about 1,250 cm.$^{-1}$ has been given[4]. By way of comparison, frequencies assigned to the covalent carbon–carbon bond in halogenated ethane derivatives, where the masses involved are comparable, range from about 820 cm.$^{-1}$ to 1,075 cm.$^{-1}$. It is, of course, not always a proper comparison merely to look at the magnitude of frequencies in complete disregard of other factors. Nevertheless, chemical data in this case would seem to indicate a lower range for the stretching frequency of the boron–nitrogen dative bond.

We have just completed a Raman spectroscopic study of the 1 : 1 complexes of borane with ammonia and the three methyl amines, including several isotopic derivatives. The preparation of ammonia borane has been described recently[5] and the mono- and di-methyl-amine derivatives were prepared in similar fashion. The preparation of the trimethyl amine compound is well known. Spectra were obtained in solution in dimethyl ether or liquid ammonia at −40° C. The boron–nitrogen stretching frequency has been identified unambiguously as a well-polarized band of medium intensity at 785 cm.$^{-1}$ in ammonia borane ($H_3N : BH_3$). Confirmation of the assignment is found in the results from the isotopic derivatives. As a first approximation, the NH_3 and BH_3 groups may be considered rigid and the ratio of the boron–nitrogen frequencies of two isotopic molecules should then be determined by the reduced masses of the pseudo-diatomic molecules. The appropriate mass ratios based on the hydrogen compound are compared in Table 1 with the frequency ratios observed. In none of the four cases is the deviation greater than about 2 per cent. The simple boron–nitrogen stretching-force constant calculated from the hydrogen compound datum to this approximation is 2·79 × 10^5 dynes/cm.

Table 1. Comparison of the Boron–Nitrogen Stretching Frequency in Isotopic Derivatives of Ammonia Borane

Compound	ν (B–N)	ν^*/ν	$\sqrt{\mu/\mu^*}$
	(cm.$^{-1}$)		
$H_3N : BH_3$	785	—	—
$H_3N : BD_3$	737	0·94	0·95
$D_3N : BH_3$	754	0·96	0·97
$D_3N : BD_3$	708	0·90	0·91
$D_3N : B^{10}D_3$	713	0·91	0·93

In the case of the methyl amine derivatives, the band in question appeared with approximately the same intensity and depolarization characteristics but with decreasing frequency as the number of methyl groups on the nitrogen increased (Fig. 1). Examination of the trimethylamine complex prepared using boron-10 in 96 per cent enrichment showed the assigned band at 667 cm.$^{-1}$ in the normal compound shifted to 676 cm.$^{-1}$ in the isotopic, whereas the previously assigned[4] band near 1,250 cm.$^{-1}$ was found to shift only 2 cm.$^{-1}$, an amount nearly within the precision of the measurements. The earlier assignment thus appears doubtful, particularly since the 1,250 cm.$^{-1}$ band is weak in the Raman effect.

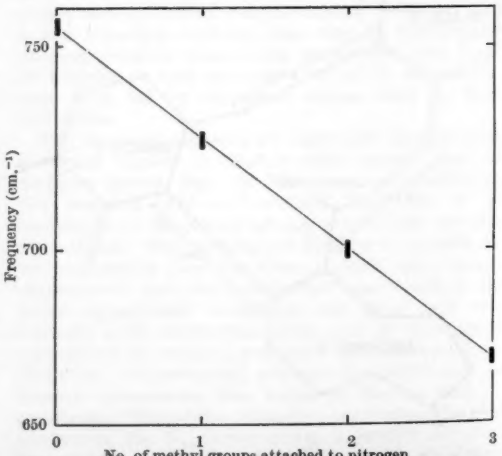

Fig. 1. The vibrational stretching frequency associated with the boron–nitrogen dative bond in some amine boranes

The spectral range within which the boron–nitrogen frequency was found in the present investigation is in good agreement with the frequencies available for other dative bonds to boron in complexes of borane with ligands such as carbon monoxide, phosphorus trifluoride and dimethyl ether.

A more complete presentation of the results will be published elsewhere. This research was supported by the Aeronautical Research Laboratory, Wright Air Development Center, Air Research and Development Command, U.S. Air Force, Wright-Patterson Air Force Base, Ohio.

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Molecular Structure of *cyclo*-Octatetraene

An investigation of the nuclear magnetic resonance absorption spectrum of solid *cyclo*-octatetraene has been made with the object of obtaining information about its molecular structure. Previous determinations of the molecular structure of *cyclo*-octatetraene have used the techniques of infra-red and Raman spectroscopy, and of electron diffraction. The results have been explained in terms of three different molecular models: (1) the 'crown' (D_4) structure with alternate double and single bonds[1]; (2) the 'crown' (D_{4d}) structure with equivalent bonds[2]; (3) the 'tub' (D_{2d}) structure with double and single bonds[3]. Subsequent investigations have supported one or other of these models, but with no real agreement as to which is the most likely structure. Theoretical predictions of the vibrational spectra and diffraction patterns of these three molecular configurations show little difference.

In certain cases, information obtained from a study of the nuclear magnetic resonance absorption spectrum can give valuable information distinguishing between various proposed molecular models. Accordingly the second moment of the proton resonance absorption line was measured at a temperature close to the melting point. The mean value obtained was $7{\cdot}9 \pm 0{\cdot}2$ gauss[2]. This has to be compared with the theoretical values calculated for each of the three different configurations. The expected second moment was also calculated for the simple planar model with equivalent bonds, although the above results showed that this was a very unlikely possibility. The results are shown in Table 1.

The C—C and C=C bonds were taken as 1·54 A. and 1·34 A. respectively. The equivalent C—C bond was taken as 1·42 A., being 2 per cent greater than the corresponding bond-length in benzene, as suggested by Bastiansen *et al.*[3]. The D_4 and D_{2d} structures were assumed to have angles of 125° between the carbon bonds, the D_{4d} structure 120° between these bonds and the plane molecule, being in the form of a regular octagon, angles of 135° between the carbon bonds. The C—H bond-length was taken as 1·07 A. for the D_4 and D_{2d} structures and as 1·08 A. for the D_{4d} and planar structures. The intermolecular contribution to the second moment (due to interactions between protons in different molecules) was calculated on the basis of the orthorhombic crystal structure found by Kaufman, Fankuchen and Mark[4], with reasonable assumptions regarding the orientation of the molecules in the cell.

Table 1

Molecular structure	Second moment of absorption lineshape in gauss[2]		
	Intramolecular	Intermolecular	Total
D_4	2·38	7·75	10·13
D_{4d}	1·99	7·05	9·04
D_{2d}	2·99	5·00	7·99
Plane	5·75	5·47	11·22

Comparison of the experimental and theoretical values for the second moment indicates that the 'tub' D_{2d} structure is the most probable one for *cyclo*-octatetraene. The D_{4d} structure gives a second moment which is more than 1 gauss[2] too large, but it must be mentioned that the intermolecular contribution to this second moment amounts to 78 per cent of the total. This is the least accurate part of the calculation because of the assumption made regarding the orientation of the molecule in the unit cell. There is, therefore, some uncertainty in the value 7·05 gauss[2] for the intermolecular part of the second moment, but it is not thought to be so large as to reduce this value by as much as 1 gauss[2].

The D_{2d} structure for *cyclo*-octatetraene has recently been confirmed using highly refined electron diffraction techniques by Bastiansen, Hedberg and Hedberg[5], reported after the completion of the present work.

The *cyclo*-octatetraene was kindly supplied by the British Oxygen Research and Development, Limited.

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Use of Molecular Sieves in Gas Chromatography for the Determination of the Normal Paraffins in Petroleum Fractions

The use of Linde molecular sieve 5*A* in conjunction with gas chromatography[1–3] offers considerable promise as a means of determining *n*-paraffins in hydrocarbon mixtures. Recently, Brenner and Coates[4] reported the application of this technique to the identification of *n*-paraffins in the C_3 to C_{11} (gasoline) range. We have successfully used it in a higher molecular weight range, namely, for the determination of the *n*-paraffin content and distribution in kerosines and gas oils. Since this may also be of general interest our method will be outlined here.

The saturated fraction of the kerosine or gas oil was separated by liquid–solid chromatography and a portion run through a 2-metre gas chromatographic

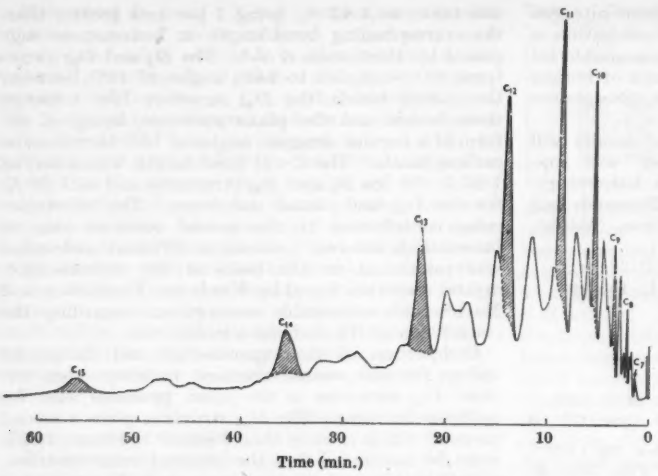

Fig. 1*a*. Chromatogram of a kerosine saturated fraction showing the *n*-paraffin peaks. Sample size, 13 μl.; column, 200 cm. × 6 mm. internal diameter, 26 per cent silicone grease *E*301 on 30–60 mesh 'Sil-o-cel' furnace brick; column temperature, 164° C.; katharometer temperature, 170° C.; carrier gas, hydrogen; outlet pressure, atmospheric

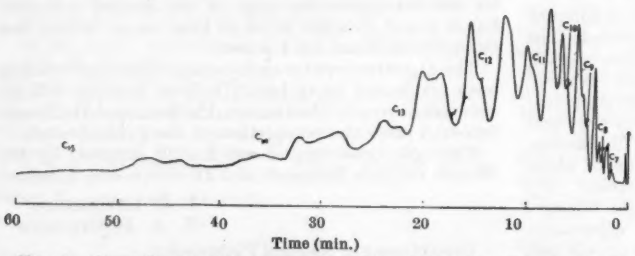

Fig. 1*b*. Chromatogram of the same kerosine saturated fraction after removal of the normal paraffins by a pre-column containing Linde molecular sieve 5*A*. Sample size, 13μl.; column, 11 cm. × 6 mm. internal diameter, 1·6 per cent squalane on 30–60 mesh molecular sieve 5*A*; 200 cm. × 6 mm. internal diameter, 26 per cent silicone grease *E*.301 on 30–60 mesh 'Sil-o-cel' furnace brick; column temperature, 164° C.; katharometer temperature, 170° C.; carrier gas, hydrogen; outlet pressure, atmospheric

Table 1

Percentage by volume	Kerosine sample					Test blend of normal paraffins	
	1	2	3	4	5	Actual composition	Composition from gas-liquid chromatography
Total *n*-paraffin by molecular sieve (liquid phase)	22	27	26	11	9		
Total *n*-paraffin by molecular sieve (gas phase)	23	31	26	12	8		
Individual *n*-paraffins							
C_7	Trace	—	—	Trace	—	—	—
C_8	1·0	0·6	0·2	0·1	0·8	—	—
C_9	4·9	3·6	0·6	0·9	1·8	3·1	3·4
C_{10}	5·3	9·2	1·8	2·3	1·7	7·7	8·3
C_{11}	4·8	8·4	6·5	2·4	1·5	22·6	22·5
C_{12}	3·9	6·2	5·5	2·2	1·1	29·8	29·7
C_{13}	1·9	2·3	4·8	1·9	0·7	22·2	22·5
C_{14}	0·9	0·5	4·0	1·3	0·4	14·6	13·6
C_{15}	0·3	0·2	1·9	0·6	—	—	—
C_{16}	—	—	0·7	0·3	—	—	—

column packed with 30–60 mesh 'Sil-o-cel' firebrick coated with 26 per cent by weight of silicone grease *E* 301 (Imperial Chemical Industries). The type of chromatogram obtained for a kerosine fraction at a column temperature of 164° C. is shown in Fig. 1*a*. The normal paraffin peaks have been shaded to show how they are superimposed upon and only partially separated from the other saturated hydrocarbons. A pre-column of 11 cm. length packed with 30–60 mesh Linde molecular sieve 5*A* coated with 1·6 per cent by weight of squalane, to prevent tailing effects, was now attached to the main column and maintained at 150° C. A further similar portion of the saturated fraction of the kerosine was run through this dual column and a second chromatogram obtained (Fig. 1*b*) free from the normal paraffins which were retained by the molecular sieve. The difference in area between the two chromatograms was a measure of the normal paraffin content, and the amount of each individual normal paraffin was similarly obtained from the difference in peak area at the respective normal paraffin elution times on the two chromatograms when using hydrogen as the carrier gas with a thermal conductivity detector. Typical results obtained are shown in Table 1 and the total normal paraffin contents are compared with those obtained by a liquid phase separation with molecular sieves.

The molecular sieve pre-columns have retained their capacity to adsorb the normal paraffins from at least 30 kerosine samples representing approximately 85 mgm. of adsorbate. It seems that the same technique could be applied to the original kerosines or gas oils and indeed to any hydrocarbon mixture which can be separated by gas chromatography. Recently, promising results have been obtained with waxes containing normal paraffins as high as C_{48} using nitrogen carrier gas and a 0·6 m. column with a 10 cm. pre-column containing the molecular sieve. As squalane could not be used to reduce tailing at high temperatures it was found that this effect could be eliminated by maintaining the pre-column at a temperature of 320° C. while the main column was operating at temperatures in the range 270–300° C.

I wish to thank the Directors of Shell Research Ltd., for permission to publish this communication, and Miss P. M. Higham and Mr. J. B. Shortall, who have taken part in the work described.

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Swift Combustion of Organic Compounds for Analysis

A NOVEL apparatus has been designed for rapid combustion of organic compounds, including volatile ones, for analysis (Fig. 1). A closed system is used, as by Mikl and Pecht[1], and Schöniger[2,3], while retaining platinum contacts as used by Pregl[4] and the usual method of taking samples.

The apparatus (patent applied for by Loughborough Glass Co., Ltd., Loughborough) consists of a quartz bulb *V*, equipped with a *B*24 joint opposite a combustion U-tube *CT*, the limbs of which are sufficiently close together to allow heating by a single flame. The flask is connected via joint *B*24 to syphon tube *T* in reservoir *R*, which can be closed with stopper *B*19 in a socket extended into a funnel *F*.

To carry out the combustion, the apparatus is flushed with oxygen. A sample between 3 and 7 mgm. is weighed, solids in boats and liquids in capillaries. The sample in its container is placed in a glass tube, one end of which is held against one orifice of tube *CT*, while the container is pushed forward with a glass rod. Capillaries are placed in tube *CT* with the open end forward. Volatile compounds are cooled by placing solid carbon dioxide externally over the sample. In the same way contacts *C* are inserted on both sides of tube *CT*. Reservoir *R* is half-filled with absorption solution, and attached to bulb *V*, a wetted 'Teflon' sleeve *TS* being slipped over the stopper, which is held by springs. Two asbestos sheets, *Asb*, are arranged over combustion tube *CT*. The platinum contacts *C* are then heated by burner *B*. Excess oxygen will escape freely through the absorption solution. When burning volatile compounds, solid carbon dioxide is kept over the sample until the contacts are glowing. Then reservoir *R* is closed with stopper *B*19, and combustion of the compound carefully started using a microburner. The rate of volatilizing can be assessed by the speed of bubbles escaping tube *T*. Combustion is completed by heating the whole length of tube *CT* with a second burner. The apparatus is left to cool, or cooled rapidly using a damp cloth. Funnel *F* is filled with distilled water and stopper *B*19 carefully lifted until the water is sucked in. The contents are shaken. Funnel *F* is filled again with distilled water and this procedure repeated four times. The absorption tube and contacts are removed, rinsed quantitatively, and the contents of the flask transferred to a container according to the analysis required. Many methods described in the literature will be found suitable for the determination of halogens and sulphur in that solution.

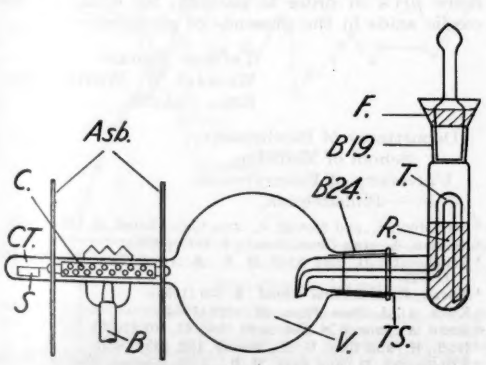

Fig. 1

Table 1

Compound	Sample (mgm.)	Percentage chlorine	
		Calc.	Found
Carbon tetrachloride	3·230	92·19	92·23
	3·600		92·26
	3·662		91·79
	4·072		92·59
Chloroform	3·150	89·10	88·71
	3·857		88·70
	3·022		89·38
	4·070		88·61
Hexachlorobenzene	4·402	74·70	74·64
	4·559		74·88
	4·776		74·46
	5·190		74·57
p-Chlorobenzoic acid	5·870	22·65	22·53
	4·540		22·76
	5·571		22·77
	4·053		22·68

Results obtained by analysis of chlorine, using the combustion procedure described, followed by potentiometrical titration with silver nitrate by Clark's method[5], are given in Table 1. Results for other halogens, sulphur and possibly phosphorus will be published later in detail.

My thanks are due to Miss P. Johnson and Mrs. V. Taylor for most efficient assistance, to Mr. Evens for skilful work in making this apparatus, to Mr. Lambie for encouragement throughout, and to the Directors of Fisons Pest Control, Ltd., for permission to publish this communication.

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Some Complex Cyanides of Rhenium

SEVERAL attempts have been made to prepare complex rhenium cyanides, but invariably these have resulted in mixed compounds. For example, in 1932 Turkiewicz[1] obtained $K_3[ReO(CN)_4OH]$, and later Morgan[2] prepared $K_3[ReO(CN)_4]$; Klemm and Frischmuth[3] and Morgan and Davis[4] described the preparation of $K_3[ReO_2(CN)_4]$. A rhenium carbonyl cyanide anion $[Re(CO)_4(CN)_2]^-$ was reported by Hieber and Schuster[5]. The only evidence in the literature for the existence of a true complex rhenium cyanide comes from polarographic studies[6,7].

We report the preparation of the binary complex rhenium octacyanides, potassium octacyanorhenate-V, $K_3Re(CN)_8$, and potassium octacyanorhenate-VI, $K_2Re(CN)_8$. With the exception of the well-known molybdenum and tungsten compounds, these are the only eight-co-ordinate cyanides, so far reported, and the first eight-co-ordinate rhenium compounds.

When potassium hexa-iodorhenate-IV, K_2ReI_6, is added to potassium cyanide in methanol, the octacyanorhenate-V is formed as a brown precipitate. Found: Re, 34·4; K, 21·9; C, 18·6; H_2O, 3·3. Required for $K_3Re(CN)_8 \cdot 1H_2O$: Re, 35·1; K, 22·1; C, 18·1; H_2O, 3·4.

Potassium octacyanorhenate-V dissolves in water to give a stable yellowish-brown solution which yields the free acid when passed through an ion exchange column.

When concentrated nitric acid is added to potassium octacyanorhenate-V solution, a reddish product can be isolated which shows a peak in its infra-red spectrum at 1,875 cm.$^{-1}$, a value which is assigned to the NO stretching frequency. Treatment of potassium octacyanorhenate-V solution with concentrated hydrochloric acid yields a purple solution. A potassium salt cannot be isolated from this solution, but addition of hexamine cobaltic chloride gives an insoluble purple precipitate which is hexammine cobaltic octacyanorhenate-VI, $[Co(NH_3)_6]_2[Re(CN)_8]_3$, the cobalt hexammine salt of the $[Re(CN)_8]^{=}$ ion. Found : Co, 7·8 ; Re, 36·0. Required for $[Co(NH_3)_6]_2$ $[Re(CN)_8]_3$: Co, 7·8 ; Re, 36·5.

The infra-red spectrum of potassium octacyanorhenate-V in 'Nujol' mull shows three cyanide-stretching frequencies at 2,140 cm.$^{-1}$, 2,110 cm.$^{-1}$ and 2,050 cm.$^{-1}$, very similar to the infra-red spectra of the molybdenum and tungsten octacyanides[5]. The spectrum also shows a sharp peak at 780 cm.$^{-1}$, which may be either a Re—C stretching mode or a C≡N wagging mode.

Potassium octacyanorhenate-V is diamagnetic. The oxidation from rhenium-IV to rhenium-V during the preparation is of some interest. Considering an octa-co-ordinate cyanide complex for rhenium-IV, of the three *d*-electrons two may enter the non-bonding stable 5*d*-orbital which is unused in σ-bonding ; the third, however, would have to enter a high-energy orbital, most likely one of the anti-bonding σ-orbitals, from which it is readily lost.

The hexammine cobaltic salt of the octacyanorhenate-VI ion is paramagnetic with a magnetic moment of 2·0 Bohr magnetons.

A detailed account of this work will be published elsewhere.

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Moving Acid Boundary (*p*H Gradient) Paper Ionophoresis of Bile Salts

Methods have been devised for the separation of bile acids and their conjugates with glycine or taurine using partition chromatography on columns[1,2] or paper[3,4]. These methods, however, may confuse certain glycine conjugated acids with the unconjugated bile acids containing a greater number of hydroxyl groups[4]. Thus ambiguous separations may result if unconjugated bile acids are also present in the mixture.

Free[5,6] and paper[7] electrophoresis with a stationary *p*H gradient has been used to separate proteins on the basis of differences in their isoelectric points. We have applied ionophoresis with a moving acid front to separate bile salt mixtures utilizing the differences in acid dissociation constants. (The pK_a's of taurocholic, glycocholic and cholic acids are respectively 1·4, 4·4 and 6·4). With this method, using a standard paper ionophoresis apparatus, a bile salt mixture can be separated into three groups : unconjugated bile acids, glycine conjugates and taurine conjugates.

The cathode compartment contains 0·05 *M* acetate buffer, *p*H 4·8 and 0·03 *M* sodium chloride. The anode compartment contains 0·05 *M* monochloroacetate buffer, *p*H 2·7, and 0·03 *M* sodium chloride. Up to 500 μgm. of the bile salt mixture is applied to a strip of Whatman No. 3 paper (6·5 cm. × 46 cm.), 15 cm. from one end. The paper is impregnated with acetate buffer and placed in the ionophoresis apparatus with the point of application nearest the cathode chamber. The separation is carried out for 16 hr. under a potential gradient of 5 V./cm.

Initially at *p*H 4·8, the conjugated bile acids migrate together toward the anode, the weaker unconjugated acids being immobile. As the separation progresses, the simultaneous migration of hydrogen ions from the anode compartment (the advancing acid front) represses the ionization of the glycine conjugates. These are consequently rendered immobile. The taurine conjugates continue to move through the acid front and are found near the anode. The glycine conjugates and the free acids are located near the middle of the paper and origin, respectively. Afterwards each area may be eluted, the substances separated, and identified by appropriate chromatographic procedure.

The presence of buffered salt mixtures in the paper may seriously interfere with the location of the bile acids by the colorimetric reagents commonly employed[8]. A reagent which has been found useful is 3 per cent (w/v) vanillin and 15 per cent (v/v) phosphoric acid in *sec*-butanol.

This method has been used to separate mixtures of pure synthetic conjugated bile acids as well as crude mixtures of natural origin. The presence of unconjugated cholic acid in the latter has been demonstrated.

The application of an effective *p*H gradient during ionophoresis promises to be of much use for the separation of compounds differing in their ionization constants as acids or bases. This method eliminates the necessity of conducting ionophoresis at two or more *p*H's in order to identify, for example, carboxylic acids in the presence of phosphate esters.

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Experimental Chemotherapy of Tumours with Hydrogen Peroxide

R. A. Holman has reported[1] that a high percentage of rats bearing Walker carcinoma 256 were cured after drinking hydrogen peroxide instead of water. These findings were not confirmed by Green and Westrop[2], nor by Ghadially and Wiseman[3] using Walker carcinoma 256 and Sheffield *RD*/3 sarcoma in rats. We have repeated Holman's experiment with some transplantable tumours of mice and rats.

Table 1. Animals and Tumours used in the Experiments

Group	Animals	Sex	Strain	Tumours	No. of animals fed: hydrogen peroxide	No. of animals fed: distilled water
I	Mice	*F*	*Br**	Transplantable solid carcinoma of the breast (G_4)	25	25
II	Mice	*F*	*A*	Transplantable adenocarcinoma of the breast (G_{44})	10	6
III	Mice	*F*	*Br**	Crocker sarcoma	15	15
IV	Mice	*F*	Hybrids	Ehrlich ascites carcinoma	14	14
V	Rats	*F*	Wistar	Guerin carcinoma	8	8
	Rats	*M*	Wistar	Guerin carcinoma	8	8

* Inbred strains from our animal colony.

One group of animals was given commercial hydrogen peroxide (diluted to final concentration of 0·45 per cent in distilled water) to drink; the other received distilled water. Both hydrogen peroxide and distilled water were supplied in dark bottles refilled every day. Both groups of animals received the standard diet used in our animal colony.

In groups I, II, III and V (Table 1), treatment with hydrogen peroxide was started 7, 3, 14 and 19 days respectively after implantation of grafts. In group IV (Ehrlich ascites carcinoma) treatment with hydrogen peroxide was started the day after transplantation.

The rate of growth of the solid tumours was expressed as a mean diameter, measurements of tumours being made two or three times a week, using Schrek's technique[4] as modified in our laboratory. In the case of Ehrlich carcinoma both groups of mice were weighed daily. In all cases the time of survival of the animals was noted.

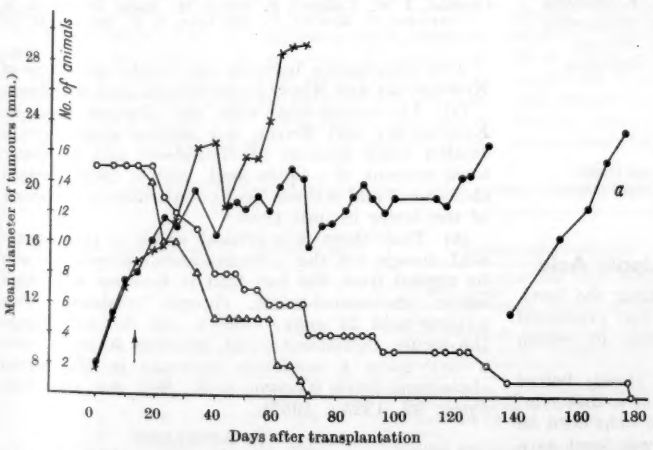

Fig. 1. Crocker sarcoma: survival time of mice receiving hydrogen peroxide (—○—) and distilled water (—△—). Rate of growth of tumours of hydrogen peroxide-treated (—●—) and control (—×—) animals; size of tumours expressed as mean diameter of tumour, averaged from tumours of animals living on a given day. The arrow indicates the start of treatment with hydrogen peroxide. Curve *a*, rate of growth of tumour in the single mouse surviving

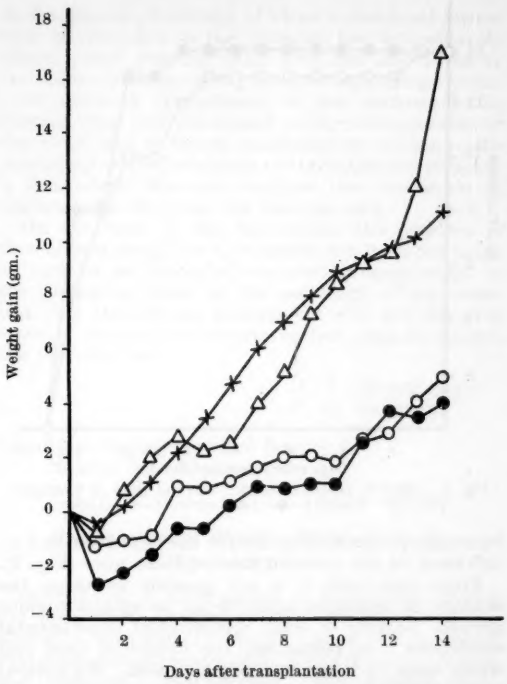

Fig. 2. Ehrlich ascites sarcoma: gain in weight of mice on hydrogen peroxide compared with those on distilled water. Experiments performed on two groups of animals: group (*a*) had an average initial weight about 25 gm., group (*b*) about 18 gm. —●—, (*a*) and —○—, (*b*), hydrogen peroxide-treated; —△—, (*a*), and —×—, (*b*), distilled water-treated

No significant effect of hydrogen peroxide on the rate of growth of tumours or on survival-time was observed in groups I, II and V. The results obtained with groups III and IV are illustrated in Figs. 1, 2 and 3.

As can be seen from Fig. 1, the rate of growth of Crocker sarcoma in mice fed on hydrogen peroxide was somewhat slower than in the control group. The regression of tumours in the treated group was not observed; however, the growth of some tumours became stationary. The effect was responsible for the prolongation of survival-time in these animals (Fig. 1). When the 'stationary period' ended, the rate of growth of the tumours of treated animals was almost as great as in control ones. This is well illustrated by the rate of growth of a tumour in the mouse which had the longest survival time (Fig. 1,*a*).

The rate of growth of Ehrlich ascites carcinoma, as expressed by the gain in weight of the animals, was diminished in the group treated with

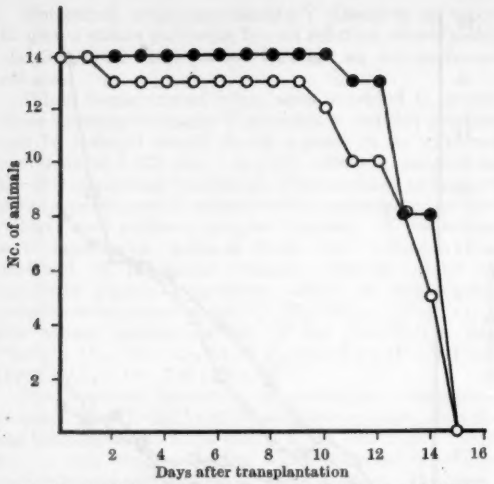

Fig. 3. Ehrlich ascites sarcoma: survival time of hydrogen peroxide – treated (—●—) and control (—○—) mice

hydrogen peroxide (Fig. 2), yet the treatment had no influence on the survival time of these mice (Fig. 3).

From this work it is not possible to assess the activity of hydrogen peroxide *per se* against tumour growth, because of some uncontrolled experimental conditions. In particular, the intake of food and water must be taken into consideration. We noticed that the intake of hydrogen peroxide solution by treated animals was much smaller than the intake of distilled water by control animals. Diminished food intake followed by loss of weight in healthy rats drinking hydrogen peroxide as compared with rats supplied with tap water was observed by Ghadially and Wiseman[3]. It seems very probable that changes in nutritional conditions brought about by drinking hydrogen peroxide (diminished food intake, or direct action of hydrogen peroxide on some essential constituents of ingested food) may be causal factors sometimes mediating an inhibitory effect on certain kinds of tumours.

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Anticholesterol Activity of α-Lipoic Acid

A recent report in *Nature*[1] concerning the 'anticholesterol' properties of α-lipoic acid has prompted communication of similar experiments in which different results were obtained.

In our work two groups of male Dutch belted rabbits (*A* and *B*) were maintained on a diet containing 2 per cent cholesterol and 6 per cent corn oil for two months. A third group (*C*) was kept as a normal control. One of these groups (*B*) also received daily intraperitoneal injections of 1 mgm. of α-lipoic acid, which represented 0·5–1 mgm./kgm. body-weight for the animals used. After eight weeks the animals were killed, the sera assayed chemically for cholesterol[2] and ultracentrifugally for β-lipoproteins[3] and the aortas graded visually (on a 0–4 scale) for atheromata. The results are shown in Table 1.

Table 1. Autopsy Results for Rabbits fed with Cholesterol

Group	No.	Atheromata (average) Arch	Thoracic	Liver weight (gm.)	Gain in weight (gm.)
A	10	2·10	1·25	93	219
B	10	2·50	1·65	90	49
C	5	0·00	0·10	63	449

Table 2. Serum of Rabbits fed with Cholesterol

Group	Average cholesterol (mgm./100 ml.)	Average lipoproteins (mgm./100 ml.) *Sf* 0–11	12–20	21–35	35–100	100–400
A	1,893	220	517	839	997	663
B	1,853	263	731	1,015	782	443
C	175	146	75	43	30	25

The most obvious source of discrepancy is the fact that Angelucci and Mascitelli-Coreandoli[1] administered considerably more α-lipoic acid than we did. In the absence of weights of the animals, it cannot be said if their rabbits showed even less weight gain than ours did. It is also worth noting that whereas their lipoic-acid group showed 20 per cent of the serum cholesterol-levels of the cholesterol-fed controls, they showed 66 per cent of the aorta cholesterol. In our work there was increased atherosclerosis in the lipoic acid group.

These results, indicating one of the lower limits at which no effect of α-lipoic is discernible, may serve as a guide in defining dosages, and may stimulate further work.

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The discrepancy between our results and those of Kritchevsky and Moyer could be explained as follows:

(*a*) In comparison with the dosages used by Kritchevsky and Moyer, our rabbits were given a smaller total amount of cholesterol and a greater total amount of α-lipoic acid, with a ratio between cholesterol and α-lipoic acid comparatively in favour of the latter in unit time.

(*b*) That there is a critical value in the α-lipoic acid dosage for the 'anticholesterol properties' can be argued from the fact that in humans with high serum cholesterol-levels, chronic treatment with α-lipoic acid 25 mgm. twice a day did not change the serum cholesterol-levels, whereas 50 mgm. once a day gave a moderate decrease in the serum cholesterol levels (Consolo *et al.*, *Boll. Soc. Ital. Biol. Sper.*, 32, 1325; 1957).

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Existence and Significance of a Physiological Anticoagulating System

When moderate doses of tissue thromboplastin are injected into the jugular vein of rats the circulating blood loses its clotting properties, with the result that no intravascular thrombi are, as a rule, produced. This effect of thromboplastin depends upon its capacity for inducing the formation of thrombin in blood from the plasma prothrombin. In most cases intravenous administration of moderate doses of thrombin to healthy animals does not cause thrombosis, for the clotting mechanism becomes disordered almost immediately after the injections. At the same time the thromboplastic activity of blood shows a sharp decrease, while fibrinogen capable of reacting with thrombin disappears and heparin-like substances appear in the blood. This protective reaction, maintaining the blood in a fluid state in the vascular bed when thrombin arises in it, is brought about by the physiological anticoagulating system. Experiments have shown that in narcotic sleep resulting from inhalation of sulphuric ether, as well as from anæsthesia produced by an intramuscular injection of novocaine on both sides of the spinal column, this anticoagulating system ceases to function. It is this effect that accounts for the fact that coagulation of circulating blood and death from thrombosis have been found to occur in anæsthetized test animals (as opposed to controls in a normal physiological condition) after an intravenous administration of certain doses of thrombin (Table 1).

It thus appears possible that there may exist certain receptors in the blood vessels which react to the presence of thrombin and actuate the neuro-humoral mechanism, preventing coagulation of the blood circulating in the vessels. There is no doubt that pathological changes in the vessel walls as well as impairment of circulation may lead to the formation of thrombin in the vascular bed. Whereas with an anticoagulating system functioning normally, the coagulation of the circulating blood is to a certain extent avoided, in any disturbance of that system the appearance of thrombin in the circulating blood, whatever its cause may be, can give rise to the formation of clots.

It is probable that the anticoagulating system partly loses its function as a result of changes in the body with age and of toxic effects occurring in case of some infectious diseases, as well as in narcosis or anæsthesia (post-operative thrombosis). The latter fact is proved experimentally. It is possible that in the normal physiology of blood a restricted formation of thrombin in the vascular bed is constantly taking place, but the blood does not clot owing to the action of the physiological anticoagulating system.

In cases of disturbance of the anticoagulating system, even with decreased prothrombin content in the blood and its slower conversion to thrombin, the possibility of the formation of thrombin still remains, a fact which does not exclude the conversion of fibrinogen to fibrin in the vascular bed.

On the basis of this hypothesis, the problem of thromboses should be approached not from the point of view of an excess of coagulating components in the circulating blood or the pathology of the vessel wall but through an analysis of the physiological state of the anticoagulating system present outside the vascular bed.

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Table 1. Inhibition of the Anticoagulating System under the Influence of Ether or Novocaine Anæsthesia

No. of animals	Activity of thrombin (sec.)*	Dose of intravenous thrombin (ml.)	Experimental conditions	No. of animals surviving	No. of animals dead from thrombosis
30	6	0·5	Animals anæsthetized with ether after 15 min. sleep	5	25
30	6	0·5	Control animals in normal physiological state	26	4
30	6	1·0	Control animals anæsthetized with ether after 15 min. sleep. Thrombin fully inactivated by heating for 6 min at 57° C.	30	0
30	6	0·5	Animals given intramuscular injections of novocaine along spinal column	11	19
30	6	0·5	Control animals in normal physiological state	26	4
30	6	0·5	Control animals given intramuscular injections of novocaine along spinal column. Thrombin fully inactivated by heating for 6 min. at 57° C.	27	3

* Thrombin solution clotted an equal volume of oxalated blood in 6 sec. at 37° C.

Carbohydrate Metabolism of Cock Spermatozoa

Glycolysis in spermatozoa of mammalian species has been much studied. These investigations, extensively reviewed by Mann[1], have demonstrated that mammalian spermatozoa utilize fructose, glucose and mannose; anaerobically, they degrade these sugars to lactic acid, deriving from this process the energy necessary for motility.

Winberg[2] demonstrated that cock spermatozoa produce lactic acid by aerobic glycolysis of glucose, fructose or mannose, and that these sugars (and also maltose to a slight extent) support their respiration, but to my knowledge glycolysis in avian spermatozoa has not been further studied systematically. This communication reports the results of an investigation on the carbohydrate metabolism of spermatozoa of the domestic cock (*Gallus domesticus*).

Semen collected from Rhode Island Red cocks by the abdominal massage method of Burrows and Quinn[3] was diluted, within 20 min. of collection, with the pre-warmed appropriate medium, and then, after removing an aliquot for initial analysis, was incubated in a water-bath at 40° C. The incubation was carried out in two ways: (1) in stoppered, 7–75-mm. test tubes containing 1–2 ml. of the mixture, which were left undisturbed in the bath, thus pro-

viding semi-anaerobic conditions, and (2) in Warburg flasks containing 2 ml. of the mixture and attached to manometers which were shaken, thus providing aerobic conditions. Most experiments were performed in a buffered avian Ringer phosphate, *p*H 7·4 (containing NaCl 0·97, $MgSO_4.7H_2O$ 0·025, $NaHCO_3$ 0·10, $NaHPO_4$ 0·1984 and KH_2PO_4 0·1815 per cent). All experiments were performed in mixtures of 3 parts diluent to 1 part of either whole semen or washed sperm resuspended to the original concentration. Total reducing substances in the mixtures were determined by the method of Hagedorn and Jensen[4] and fructose by the resorcinol method of Roe[5] as adapted to semen by Mann[6] in protein-free filtrates obtained by using barium hydroxide and zinc sulphate.

Although cock semen is notoriously poor in fructose[1], mixtures of cock semen and Ringer phosphate to which fructose was added in a concentration of 3·0 mgm. per ml. utilized fructose at the rate of 0·63–0·76 mgm. per 10^9 sperm during the first hour under semi-anaerobic conditions. Aerobically, 0·42–0·55 mgm. fructose was utilized by 10^9 sperm during the same period. Curves of utilization of fructose were not linear, presumably due to progressive inactivation of incubated spermatozoa and gradual depletion of the substrate. For example, in mixtures containing about $1·5 \times 10^9$ sperm per ml. an average of 39 per cent of fructose was utilized during the first hour, 21 per cent during the second and a further 18 per cent during the third hour.

In order to determine whether cock spermatozoa, like those of bull and ram, utilize aldoses preferentially to fructose, cock spermatozoa were incubated in mixtures containing 3 mgm. fructose plus 6 mgm. of either glucose or mannose per ml. Surprisingly, in these mixtures no decrease in fructose whatever could be observed, and, in fact, the fructose content appeared to increase slightly. In a subsequent series of incubations carried out in diluents containing either glucose or mannose as the sole sugar, a definite accumulation of fructose was readily demonstrable. A typical experiment is illustrated in Fig. 1. In this experiment a 1 : 3 mixture of cock semen and Ringer phosphate, supplemented with 3 mgm. glucose per ml., during 3 hr. aerobic incubation at 40° C. produced 0·98 mgm. fructose per ml., which represents a conversion of more than 30 per cent of glucose into fructose. At the end of incubation the mixture contained more than twice as much fructose as glucose. The identity of fructose was confirmed by the yeast-fermentation test.

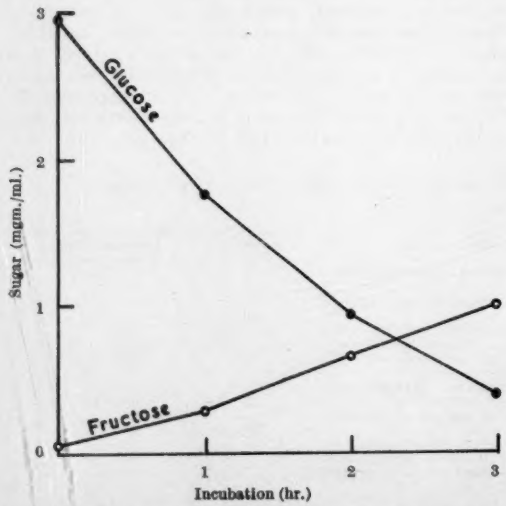

Fig. 1. Glucose utilization and fructose formation by diluted cock semen during aerobic incubation at 40° C.

Under the experimental conditions referred to in Fig. 1 the rate of formation of fructose was found to be approximately twice as high in aerobic as in anaerobic conditions. It was also found to be fairly independent of the initial concentration of aldose, at least over a certain range. When, however, the initial concentration of aldose was very small the rate of accumulation of fructose was much smaller. An average of 0·17 mgm. of fructose accumulated during the first hour in the presence of 2–6 mgm. aldose, but when the initial supply was limited to 0·8 mgm., only 0·06 mgm. fructose accumulated during the first hour and most of this disappeared during the second.

The formation of fructose in cock semen supplemented with glucose was found to be dependent on the presence of live spermatozoa. It was also demonstrated in suspensions of washed but motile spermatozoa. A pooled sample of semen was centrifuged, the packed cells suspended in Ringer phosphate, the suspension divided into two equal portions and both portions centrifuged. One portion was resuspended in half the original volume of seminal plasma and the other in the corresponding volume of Ringer phosphate. Samples of each were incubated with glucose and with mannose, each sugar at an initial concentration of 3 mgm. per ml. During the first hour 0·20 mgm. fructose was formed from either glucose or mannose in the presence of seminal plasma and 0·21 mgm. in the presence of Ringer phosphate; after 3 hr., respectively 0·75 and 0·68 mgm. fructose had accumulated.

Since cock spermatozoa convert glucose and mannose to fructose the question arises whether they are also able to carry out the reverse reaction. The existence of such a reverse reaction could not be demonstrated, at least under aerobic conditions. In cock semen incubated for 3 hr. with 3 mgm. fructose per ml. 0·98 mgm fructose disappeared while the level of reducing substances other than fructose declined from 0·47 to 0·20 mgm. per ml. Under semi-anaerobic conditions the results were less clear. Here small but irregular amounts of non-fructose reducing material accumulated, but much of it proved to be non-fermentable by yeast.

This investigation was conducted during my tenure of a National Science Foundation Fellowship while on sabbatical leave from the University of California, Davis, California. The cordial and invaluable interest and advice of Dr. T. Mann throughout the investigation are gratefully acknowledged.

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Distribution of Newly Synthesized Deoxyribonucleic Acid in Mitotic Division

Firket and Verly recently presented[1] some results on the labelling of chromosomal deoxyribonucleic acid in chick fibroblast cells with tritiated thymidine. One of their conclusions is that their results support the hypothesis of the equal distribution of labelled, and hence newly synthesized, deoxyribonucleic acid between sister anaphase and telophase chromosome sets and contradict an earlier observation by Mazia and me[2] that this distribution may be decidedly unequal.

An inequality which exceeds that to be expected from the random distribution of the products of replication of different chromosomes and from the random distribution of decaying isotopic atoms suggests that there is an additional variant: a daughter chromosome may differ from its sister in the amount of newly synthesized deoxyribonucleic acid; in other words, the formation of daughter chromosomes from the maternal complex involves the random assortment of a small number of new and old units of deoxyribonucleic acid. This was the conclusion reached by us from an analysis which involved a mitotic system of six chromosomes and thymidine-^{14}C as the deoxyribonucleic acid marker[2].

A more direct approach to the problem was carried out by Taylor *et al.*[3]: tritiated thymidine was substituted for thymidine-^{14}C, thus permitting the autoradiographic analysis of single pairs of sister chromosomes rather than whole sets. Their conclusion was that sister chromosomes always shared equally in the deoxyribonucleic acid most recently synthesized, that the formation of daughter chromosomes did not involve the random assortment of the new and old structural units of the deoxyribonucleic acid of the mother complex. More recent experiments of mine strongly suggest, however, that these latter results are rather more complex than first appeared, that they are subject to a different interpretation from that offered by Taylor *et al.*[3], and that they by no means exclude the earlier conclusion of random assortment. In short, the question of the mode by which the mother chromosome is transformed into its two daughters is still unresolved and in need of further experimental elucidation.

The study of Firket and Verly[1] has a direct bearing on this question: if significant anaphase and telophase inequality of newly synthesized deoxyribonucleic acid is ruled out, then an equal partition of the material between daughter chromosomes is indicated. I should like to point out, however, that the experimental system chosen by these authors makes it virtually impossible to arrive at any significant quantitative conclusions. Unlike the experiment of Taylor *et al.*[3], the study by Firket and Verly looks at whole sets of post-metaphase chromosomes. In this respect it resembles our earlier investigation of the six-chromosome system (*Crepis capillaris*). In sharp contrast with the latter, however, the chick fibroblast cell presents a very difficult statistical problem indeed: with upwards of 60 chromosomes the number of cells that must be analysed in order to separate the random inequalities introduced by the independent behaviour of different chromosomes from those which might be introduced by the segregation of chromosomal sub-units is extremely large. Similarly, the number of grains in the autoradiographic image should be large enough to permit the statistical separation of random distribution and decay errors from biologically significant inequality. The actual results on which Firket and Verly base their conclusion[4] suggest that neither of these conditions is fulfilled. The number of cells analysed is 19, the average number of silver grains in the emulsion per cell is 47. In such a sample of a mitotic distribution system with 60 or more chromosomes one cannot hope to detect inequalities which are ascribable to differential labelling of sister chromosomes. The only conclusion which can be drawn from these results is that newly synthesized deoxyribonucleic acid is distributed between post-metaphase chromosome sets in chick fibroblast cells. The question of the equality or inequality of this distribution remains unelucidated.

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I agree with Dr. Plaut that my results, though different from his, do not rule out the conclusions arrived at by him and Dr. Mazia. In fact, in the detailed paper[1] to which he refers, I wrote (p. 84): "Même si cette [Dr. Plaut and Mazia's] hypothèse sur la duplication de l'ADN est exacte, une telle déviation n'aurait qu'une chance infime d'apparaître dans les cellules de Poulet où le nombre de chromosomes est beaucoup plus élevé". I doubt the conclusions of their experiments for other reasons: namely, the inaccuracy of the limits of the field to be measured, the various possible errors in the quantitative assessment of radioactivity, and the contrary experiments by Taylor *et al.*[2].

I quite agree, however, that no definite conclusions have yet been reached about the mode of distribution of new deoxyribonucleic acid among daughter chromosomes. It is both a difficult and important problem with far-reaching consequences. If a deoxyribonucleic acid unit is defined as a molecule or group of molecules that are synthesized and tied together, the possible hypotheses are as follows:

(*a*) The number of deoxyribonucleic acid units per chromosome is small and there is a mechanism that ensures a perfectly equal distribution of newly synthesized labelled units and old units among daughter chromosomes. This implies a definite spatial relationship between these units (or, less likely, a system that can distinguish between new and old units of identical composition).

(*b*) The number of units is small and they are randomly distributed among daughter chromosomes. On the average, two sister chromosomes have an equal amount of new and old deoxyribonucleic acid, but some pairs may show a very unequal distribution.

(*c*) The number of units per chromosome is large and there is a random distribution.

(*d*) The number of units is large but there is a tendency for the newly synthesized units to move together.

The experiments of Taylor *et al.* tend to prove hypothesis (*a*). Plaut and Mazia's results[3], taken at their face value, point to (*b*) or (*d*). Mine agree best with (*a*) and (*c*). It should also be borne in mind

that there may be no single pattern of universal application.

Contrary to what Plaut and Mazia[3] say, all these hypotheses are compatible with the Watson and Crick hypothesis of duplication of deoxyribonucleic acid molecules: a simple calculation shows there are usually several thousands of these per chromosome, so that a different order of magnitude is involved.

Crucial experiments are difficult to devise in this field where matters are complicated by errors due to the random decay of the isotopes and to the methods of quantitative assessment of radioactivity. It seems, however, that if hypothesis (*b*) is correct, we should find some unlabelled anaphase chromosomes (in a species where their number is large) after one premitotic synthesis in the presence of a radioactive precursor. If in such an experiment *all* chromosomes are labelled, hypothesis (*b*) becomes extremely unlikely. With the precise localization given by tritiated thymidine (but not with thymidine labelled with carbon-14), such an experiment now seems possible and I intend to try to tackle the matter shortly.

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Comparison of the Salivary Secretion of Both Parotid Glands in a Sheep

Numerous workers have shown that the parotid glands of ruminants secrete saliva continuously, but only a small number of observations have been made on the secretion of both glands in the one animal. Scheunert and his colleagues[1] observed that the two parotids of sheep secrete independently of one another and considered it probable that the fistulated parotid secretes only a minimal amount of saliva. Colin[2] ascribed the differences in the secretion of the two parotid glands which he observed in the case of an ox to the preference on the part of the animal for chewing on the non-operated side.

In the course of investigations on the return of nitrogen to the rumen in the parotid saliva of sheep, the secretion from both parotid glands in a Merino wether was measured over fourteen days. Into each duct two cannulæ were inserted, one directed towards the gland, the other towards the orifice on the buccal mucosa. The free ends of the cannula on either side could be joined so that the saliva was able to flow into the mouth from one gland, while that from the opposite member was being collected. By reversing the opening and closing of the bridge from side to side, the daily secretion from each parotid gland was measured on alternate days. In this way the animal received the secretion from one gland at all times.

The collections were commenced three days after the surgical operation and continued for the following fourteen days. During this time the animal consumed the whole of its daily ration of 680 gm. of dry matter composed of sheep cubes, oat grain, oat chaff and lucerne hay. The animal had free access to water. Instead of giving the sheep a daily ruminal infusion of sodium bicarbonate to replace the sodium lost in the secretion from the operating gland, the remainder of the saliva collected, after samples had been kept for nitrogen analysis, was infused back into the rumen per cannulum at a rate simulating the natural flow.

For the duration of the experiment the animal was kept under the same environmental conditions to which it had been accustomed for the previous six months and maintained the same position in relation to its regular neighbours in the colony. It was attended by only one member of the department.

Under these conditions the daily volume was recorded for each gland on alternate days and the nitrogen content of the saliva determined by the micro-Kjeldahl method. The results are given in Table 1.

Table 1

Saliva	Left gland	Right gland
Total volume for 7 days (ml.)	16,665	17,468
Mean daily volume (ml.)	2,381 ± 94·3*	2,495 ± 94·3*
Range in daily volume (ml.)	1,992–2,745	2,268–2,775
Total nitrogen content for 7 days (mgm.)	2,076	2,007
Mean daily nitrogen (mgm.)	297 ± 10·6*	287 ± 10·6*
Range in daily nitrogen (mgm.)	257–327	251–341

* Standard error of mean

The mean daily volume of the left and right gland did not differ significantly (*t*, 0·86 on 12 degrees of freedom). Similarly in the case of the mean daily output of nitrogen, the left and right gland did not differ significantly (*t*, 0·66 on 12 degrees of freedom).

The mean daily volume of saliva and nitrogen content accord well with similar values recorded for sheep with permanent unilateral parotid fistulæ kept under the same feeding and environmental conditions at this Institute. Denton[3] has reported that the daily volume of saliva secreted by sheep with permanent unilateral parotid fistulæ is relatively constant on any one diet. However, the volume collected daily varies with the diet[4].

Both parotid glands continued to function for a further nine days until on the twenty-sixth day after the operation one of the cannulæ became dislodged. During the whole period of observation the animal did not appear to suffer any overt ill effect from the presence of the cannulæ in the ducts. It remained in good health, ruminated normally, and passed fæces of uniform consistency. Over the twenty-six days of observation the sheep gained 2·5 lb. in weight.

The procedure adopted of infusing the animal's own saliva back into the rumen as a continuous flow was designed to approximate the secretion of the saliva under normal physiological conditions and thus maintain the buffered fluid environment in the rumen. As an alternative I have observed that sheep with permanent unilateral parotid fistulæ will drink their own saliva, or that from another animal, and remain in a healthy condition without a daily supplement of sodium bicarbonate.

The significance of the salivary nitrogen contribution to the rumen under different dietary conditions will be discussed elsewhere.

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Desertomycin, a New Crystalline Antibiotic with Antibacterial and Cytostatic Action

A REPORT was recently published[1] of a new antifungal antibiotic, flavofungin, from a previously unreported *Streptomyces* strain, *Streptomyces flavofungini*. This species produces, besides flavofungin, another antibiotic. Its presence was demonstrated by the paper-chromatographic examination of the fermentation fluid and of the crude flavofungin. The *Streptomyces* strain originally isolated produces much more of this antibiotic than of flavofungin, in contrast to its natural variant, which synthesizes flavofungin more abundantly. The second antibiotic can be extracted from the fermentation broth as well as from the mycelium with organic solvents. We succeeded in obtaining hexagonal crystals from various solvent systems (Fig. 1). This new antibiotic was named 'desertomycin', after the source (African desert sand) of the *Streptomyces* strain which produces it.

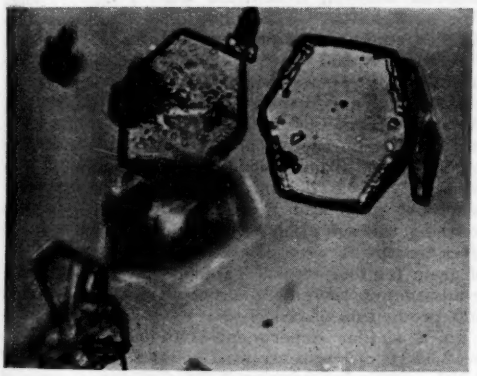

Fig. 1 Desertomycin crystals

Desertomycin is a uniform snow-white, glittering, crystalline product. Its tentative empirical formula is: $C_{33}H_{60-62}O_{14}N$. It melts at 189–190° C. The solubility in water or in absolute alcohols, ether and acetone is low, but it is higher in alcohols which contain some water. Its neutral aqueous solution is very stable. Desertomycin contains no sulphur, halogen, N-methyl or acetyl groups, but it has a C methyl group. The substance gives acetylated and hydrogenated derivatives; it decolorizes a solution of permanganate or bromine and gives positive ninhydrin and Kuhn–Roth C-methyl tests.

Crystalline desertomycin was tested against a number of bacteria by a serial dilution method. The minimum inhibitory concentration varies between 5 and 25 μgm./ml. for various micro-organisms. The antimicrobial activity of desertomycin is shown in Table 1.

Desertomycin proved to be markedly toxic for mice. The intravenous, intraperitoneal, subcutaneous and oral *LD*50 of desertomycin in mice was found to be 1·35 mgm./kgm., 2·6 mgm./kgm., 5·3 mgm./kgm. and 12–15 mgm./kgm. body-weight, respectively.

Desertomycin exhibits a very significant cytotoxic effect. Our *in vitro* experiments show that it inhibits the life-activity of leukæmic cells and of Ehrlich ascites cells in a quantity of 0·7 μgm. and 10 μgm., respectively[2]. It exhibits a cytostatic (10 μgm.) and in higher concentrations (50–100 μgm.) a cytolytic action on fibroblast, HeLa and Crocker cells, studied by the tissue culture method (Kelner, B., *et al.*, personal communication). Once more the inhibition of the growth of bacteria is seen to be connected with the inhibition of tumour cells.

Table 1

Micro-organism	Inhibitory concentration (μgm./ml.)
B. subtilis, NTCC 6633	1–5
B. subtilis (streptomycin resistant)	1–5
B. subtilis (penicillinase producing)	1–5
B. megatherium	1–5
Staphylococcus aureus Duncan	10
Staphylococcus aureus (penicillin resistant) (three strains)	10
B. cereus 569	10
E. coli 111	10–25
E. coli S. (mouse-pathogen)	10–25
Staphylococcus aureus (mouse-pathogen) (two strains)	25
Staphylococcus aureus (four strains)	25
Staphylococcus aureus (poly-resistant)	25
Staphylococcus aureus (penicillin resistant) (five strains)	25
Micrococcus ureae	25
Enterococcus	>25
E. typhosa H	>25
E. coli commune	>25
Pneumobacillus Friedländer	>25
Pseudomonas pyocyanea	not inhibited

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Adrenalectomy and Tissue Amines

WE have recently suggested[1] that the secretion of the adrenal cortex exerts a functional control over the levels in tissue of both histamine and 5-hydroxytryptamine. This evidence was obtained by injecting synthetic corticosteroid substances into normal rats as well as into rats in which tissue histamine had been previously depleted. Further experiments have now been carried out on animals the adrenal glands of which have been removed before drug treatment.

Groups of rats (100–125 gm. in weight) were bilaterally adrenalectomized and maintained for four days on a cube diet and either drinking water or normal saline solution. Other groups were mock-adrenalectomized and similarly maintained. The animals were then killed and several tissues extracted and tested for histamine and 5-hydroxytryptamine activity. Striking differences between the amine-levels in the groups were noted. Whereas the histamine-levels in the skin, ears, feet, liver and lung of adrenalectomized rats maintained on normal saline solution did not differ significantly from those of mock-adrenalectomized animals, the histamine-levels in these tissues of adrenalectomized rats maintained on water were increased two to six times. When cortisone (but not deoxycorticosterone acetate) was given to such animals, the histamine-levels in the tissues fell dramatically to normal levels or below. This is therefore a further demonstration of the control exerted by glucocorticoid substances on tissue histamine-levels, and as suggested by Schayer and his

co-workers[2] these substances probably alter the rate of formation of histamine in the tissues. In a similar manner, there is a two-fold increase in the 5-hydroxytryptamine-levels in the tissues of adrenalectomized rats maintained on drinking water, and cortisone treatment restores these levels to normal. The changes in the 5-hydroxytryptamine-levels might be magnified if the experiment can be performed on histamine-depleted adrenalectomized rats maintained on drinking water, but such rats have not so far been available.

These results support our hypothesis[1]. They further show that the tissue-levels of both histamine and 5-hydroxytryptamine are in part inversely related to the sodium intake. The importance of the dietary sodium content when studying the effect of adrenalectomy on tissue histamine-levels was shown by Rose and Browne[3], but neglect of this factor by later workers led to several conflicting results. In assessing the effect of corticosteroids on conditions of inflammation, conflict has also arisen due to lack of appreciation of the role of tissue amines in certain of these conditions and of the control exerted upon these amines by the hormones of the adrenal gland and their analogues. It is of interest that in the present experiments the fluctuations in the 5-hydroxytryptamine-levels in the rat follow those in the histamine-levels, and in this respect are similar to those noted already in other forms of stress such as weaning, pregnancy and hyperthyroidism[4].

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Lethal and Sterilizing Effects of Single and Fractionated Doses of Gamma Radiation on *Calandra granaria* L.

Two techniques for radiation disinfestation can be distinguished: the direct irradiation of infested products[1], and the indirect control of a pest species by the release of sterilized adults[2]. The successful operation of the first method necessitates complete and permanent reproductive sterilization accompanied by premature death; and the second, sterilization without seriously affecting the longevity of the released adults.

The susceptibility of a number of insect species to large single doses of gamma radiation has been examined[3]. Small daily doses of X-rays[4] and γ-rays[5] have been shown to increase the longevity of the flour beetle (*Tribolium confusum* Duv.). Again, the sterilizing dose for the parasitic wasp (*Habrobracon juglandis* (Ashmead)) does not cause permanent infertility when fractionated with suitable time intervals between treatments[6]. As part of a broader project to examine the radiation susceptibility of grain weevils, preliminary experiments were carried out to compare the effects of single and fractionated doses of γ-radiation on larvæ and adult *C. granaria*. Insects were irradiated with a cobalt-60 source providing a dose-rate of 6×10^3 r./hr. Cultures were maintained on preconditioned grain at 26° C. and 75 per cent relative humidity.

Table 1. The Effects of Irradiating Larvæ of *C. granaria* with a Single Dose of 4,012 rep and Five Repeated Doses of 802 rep on Adult Emergence, Survival and Progeny Production

Treatment	Batches, each of 450 larvæ	Mean No. of adults emerged	Adult survival four weeks after emergence (per cent)	No. of progeny
Control *A*	2	105·0±5·5	99·1± 0·9	2,187± 59
Control *B*	6	115·0±3·3	98·9± 0·4	2,208± 40
Intervals between repeated doses:				
1 day	2	103·0±5·0	97·0± 2·1	1,621±213
1 hr.	1	47	66·0	51
10 min.	1	5	20·0	0
1 min.	1	2	50·0	0
Single dose	4	2·5±1·0	23·3±14·5	0

In the first experiment, batches of larvæ in grain were treated with a single dose of 4,012 rep and others with five repeated doses of 802 rep; the time intervals between treatments were 1 and 10 min., 1 hr. and 1 day. The single dose was applied to samples containing equal proportions of 7–8, 8–9, 9–10, 10–11 and 11–12 day-old larvæ. Similar samples were used when the intervals between repeated doses were 1 hr. or less. With daily doses, the first treatment was given to 7–8 day-old larvæ and the last on the eleventh to twelfth day of their development. Two types of untreated controls were used: *A*, larvæ 7–8 days old when the first daily dose was given and *B*, equal proportions of larvæ covering the age-range. The adults which emerged after treatment were placed to oviposit on 100 gm. of grain for four weeks. Table 1 shows the effects of irradiation on the emergence of adults, their survival and production of progeny.

In a similar experiment, batches of 50 adults 7–12 days old were treated with a single dose of 5,666 rep and others with five repeated doses of 1,133 rep; the 1-hr. interval between treatments was omitted. Controls *A* and *B* were used as in the first experiment. After irradiation the adults were placed to oviposit on 100 gm. of grain and the number of survivors counted four weeks later. Progeny were recorded 7 and 9 weeks after inoculation (Table 2).

Table 1 shows that when young larvæ are treated with a single dose and with doses fractionated by intervals of 1 and 10 min., adult emergence is markedly reduced; more adults emerge when the interval is increased to 1 hr., while with daily doses emergence is unaffected. These results suggest the existence of a recovery process which becomes completely effective a few hours after treatment.

Table 2. The Effects of Irradiating Adult *C. granaria* with a Single Dose of 5,666 rep and Five Repeated Doses of 1,133 rep on Survival and Progeny Production

Treatment	Batches, each of 50 adults	Mean survival after four weeks (per cent)	Mean No. of progeny (weeks after inoculation)	
			7 weeks	Total at 9 weeks
Control *A*	8	97·5±0·8	1,083±88·0	1,720±112·0
Control *B*	14	97·0±1·0	1,106±51·0	1,766± 48·0
Intervals between repeated doses:				
1 day	4	97·5±1·9	14± 0·6	53± 5·4
10 min.	3	10·7±0·7	10± 0·4	12± 0·6
1 min.	3	11·3±2·4	12± 3·0	14± 4·3
Single dose	7	5·1±1·1	11± 0·6	12± 0·8

Table 1 also shows that the survival of adults and production of progeny are similarly affected.

Table 2 shows that the survival of adults which are treated with fractionated doses is also similar to that obtained with a single dose if the interval between treatments does not exceed 10 min.; furthermore, after treatment with daily doses their survival is similar to the controls. Production of progeny, however, is seriously reduced by both single and fractionated doses, irrespective of their duration, and in this respect adults and larvæ differ markedly in susceptibility. However, the difference in progeny counts at 7 weeks and at 9 weeks suggest that fertility may reappear in adults receiving daily doses. The difference in behaviour of larvæ and adults may be attributed to the condition of gonadial development at the time of irradiation and warrants further investigation.

The present results are of importance in relation to the operation of the two techniques for radiation disinfestation. Thus, the efficacy of direct irradiation of infested products could be seriously jeopardized by the use of repeated passes if intervals between doses are longer than a few minutes. On the other hand, an increase in longevity, obtained by using fractionated doses at daily intervals, could considerably increase the efficiency of insect control by the release of sterile adults provided permanent sterilization was achieved.

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Dosage–Mortality Curves for Houseflies Susceptible and Resistant to DDT

A recent paper by Hewlett[1] has directed attention to the fact that the slopes of dosage–mortality curves for houseflies resistant to DDT are less steep than those for houseflies susceptible to DDT; he explained this in terms of (1) the relation between the amount of DDT absorbed by flies and the external dose; and (2) a possible variation from fly to fly of the DDT exerting a toxic effect at the primary site of action, a variation brought about or intensified by enzymatic detoxification of DDT in resistant flies. An alternative explanation of the phenomenon would be that DDT resistance in houseflies is genetically controlled, and that very few of the strains of insects so far examined represent genetically pure lines.

Let us take the case of an insect the resistance of which is governed by a single incompletely dominant gene *R*. Possible genotypes are then *RR*, *Rr* and *rr*. Even if the fully susceptible *rr* genotype is eliminated in each generation, the progeny of the heterozygote cross *Rr* × *Rr* will consist of 25 per cent of fully susceptible individuals. Unless, therefore, a pure line of *RR* constitution can be isolated from its allelomorphs, a dosage–mortality test of flies of a given generation will show a response of individuals ranging from complete susceptibility to the highest resistance expressible by the gene in question. Since in Nature the occurrence of resistance genes is normally so low that in an average sample of wild insects none will be found, the control will therefore represent a purer line of susceptibility than the resistant does of resistance. The difference in the slopes of the two dosage–mortality curves is therefore representative principally of the difference between the pure and the impure samples.

In the case of polygenic resistance, due to a number of weak genes acting together—to which type of resistance most cases of housefly resistance apparently belong—the picture is similar, but less simple. Let us take the case of two independently segregating partially dominant resistance genes *R* and *P*. There are then nine different possible genotypes, ranging from the highest resistance *RRPP* to the lowest (fully susceptible) *rrpp*, all of which may appear in any new generation. Given three genes, 27 possible combinations may occur. Separation of the genotypes is then virtually impossible, for any mass selection technique of exposure of a given generation to insecticide may still leave some heterozygotes alive, which will give rise to susceptibles and further heterozygotes at the next generation.

In the case of a pure line the difference between the *LD*0 and the *LD*100, that is, the slope of the curve, will be dependent entirely upon the inherent errors in the methods of sampling and testing, plus a certain fly-to-fly variation. In the case of a mixed strain, this difference will obviously be greater by the extent to which the component genotypes differ one from another. However, the establishment of a greater number of points on the dosage–mortality curve, that is, by testing a greater number of dosages intermediate between *LD*0 and *LD*100, may lead to the resolution of the gently sloping resistance curve into several parallel curves equal to the number of the genotypes present.

Fig. 1 shows the three separate log-probit regression lines for the three genotypes of the Western Sokoto strain of *A. gambiae* exposed to various concentrations of gamma-BHC. Resistance to dieldrin and BHC has been shown to be monofactorially inherited and incompletely dominant in this strain[2]. Super-imposed on these three regression lines is the graph for an F_2

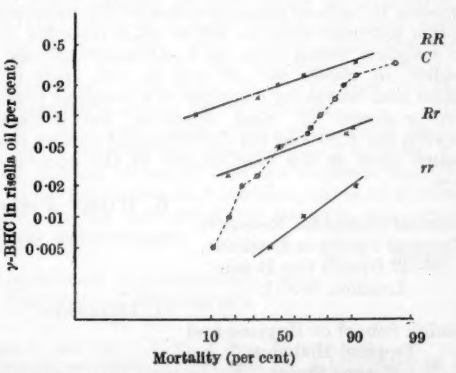

Fig. 1. Log-probit regression lines for susceptible (*rr*) hybrid (*Rr*) and resistant (*RR*) strains of *A. gambiae* exposed for 1 hr. to varying concentrations of gamma-BHC in risella oil and calculated percentage mortalities in a theoretical F_2 generation composed of 25 per cent susceptibles, 50 per cent hybrids and 25 per cent resistants (*C*)

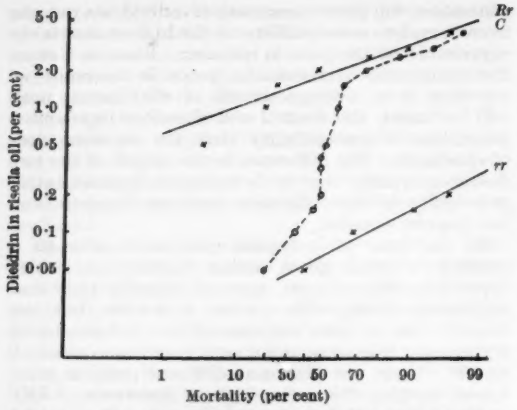

Fig. 2. Log-probit regression lines for susceptible (*rr*) and hybrid (*Rr*) strains of *A. gambiae* exposed for 1 hr. to varying concentrations of dieldrin in risella oil and calculated percentage mortalities in the theoretical backcross offspring (50 per cent susceptibles and 50 per cent hybrids) of a hybrid to the susceptible parent (*C*)

generation, composed of the theoretical 25 per cent susceptibles, 50 per cent hybrids and 25 per cent resistants, based on the actual mortalities recorded for the separate strains. A tripartite segregation of this graph is indicated though not too obviously and the points could be taken as lying on a single straight line. The explanation for this is that the degree of resistance to gamma-BHC is of a comparatively low order (some thirty times) and the gaps between the *LD*100 of the susceptibles and *LD*0 of the hybrids and *LD*100 of the hybrids and the *LD*0 of the resistants are very small. Resistance to dieldrin is much higher (some 800 times) and Fig. 2 shows the regression line for the theoretical offspring of the backcross of hybrids with the susceptible parent (50 per cent susceptibles and 50 per cent hybrids) based on mortalities recorded among susceptible and hybrid strains. A definite step in the line separating the susceptible part of the population and the hybrid part is apparent, where an increase in dosage produces no increase in kill (0·1–0·4 per cent dieldrin). As the degree of resistance to dieldrin is so high it is not possible to show the regression line for the resistant strain on this graph, where mortalities have been recorded after one hour's exposure to various concentrations of the insecticide. At this exposure time no kill at all is recorded with the resistant strain even on a saturated solution of dieldrin in risella oil. It will be seen from these graphs that on taking a sample of a resistant population produced by mass selection, the difference between the *LD*0 and the *LD*100 would be very much greater than in the case of any of the component lines.

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The paper of mine referred to pointed out that it was not yet possible to say whether the two effects discussed would account for the whole of the differences between the slopes of probit–log-dose lines for houseflies resistant and susceptible to DDT. Additional genetic heterogeneity in strains of resistant flies could, it seems, operate side by side with the other two effects in reducing the slopes of the lines; it might also intensify the second of the other two effects. When applied to resistant flies with DDT, *bis*(*p*-chlorophenyl) methyl carbinol synergizes the action of the DDT by depressing its enzymatic detoxification[1,2], and at the same time increases the slope of the line relating probit mortality to the log-dose of DDT[2]; this strongly suggests that the detoxification mechanism is directly concerned in depressing the slope of the line for DDT without synergist, as discussed in my paper.

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Ecology of the Louse *Lepidophthirus macrorhini* Enderlein 1904 on the Elephant Seal *Mirounga leonina* (L.)

The Australian National Antarctic Research Expeditions have maintained a station since 1948 on Macquarie Island, which is situated in the South Pacific, 54° 30′ S., 159° E. Through the courtesy of the director, Mr. P. G. Law, a visit was paid to the island in December 1957. This afforded an opportunity to obtain some information on the ecology of the louse *Lepidophthirus macrorhini* Enderlein 1904 which infests the elephant seal, *Mirounga leonina* (L.). Living lice were brought back to the laboratory for study by keeping infested hind flippers in a refrigerator.

Unlike other species of lice, *L. macrorhini* forces its way into the skin and creates a burrow under the stratum corneum of the epidermis. Single nymphs or adults were found in these burrows, usually with the posterior tip of the abdomen visible. Occasionally the burrows were half an inch in length. In addition, a copulating male and female were found in one burrow, and in two others, each inhabited by a single female, an egg was found. When the elephant seal moults the stratum corneum of the epidermis is shed intact with hairs attached. Although some lice are lost at this time many remain, since only the roof of the burrow which they inhabit is removed.

Pup seals were found to be the most heavily infested and the region of densest infestation was the hind flippers. From examinations made while the pups slept on the beach, it appeared that all were infested with lice.

The skin temperature of elephant seal pups and bulls (2–7 years old) resting on the beach was found to be between 27° C. and 34° C. Two pups were driven into the sea, after their skin temperatures had been taken, and restrained in 3 ft. of water by a lassoo around the neck. On entering the water their skin temperatures dropped to between 10° C. and 12·5° C., that is, a few degrees above the temperature of the sea, 8·5° C. These observations agree with those of Irving and Hart[1] on the harbour seal *Phoca vitulina* and the harp seal *Phoca groenlandica*.

In the laboratory it was found that the lice became inactive either in air or water at 10° C. When placed in moist air at 29° C., after an exposure to low temperatures for several days, normal activity did not return until after a few hours. Their oxygen consumption in air at 10° C., measured by a Warburg apparatus, dropped to at least a fifteenth of that at 33° C., and they survived a five-day immersion in sea-water at 10° C. which was only about 7 per cent saturated with oxygen (0·53 ml. oxygen per litre). Thus, at low temperature their metabolic rate was considerably reduced. It therefore appears likely that the skin temperature of the host is the primary factor which influences the growth of a population of these lice and that the main increase occurs when the skin temperature is highest, namely, when the elephant seal is on land. As a consequence, the age group which spends the longest continuous period ashore might be expected to become the most heavily infested. Pups comprised this group at Macquarie Island in December 1957.

It has been suggested that when the seal is at sea the lice obtain oxygen from a film of air trapped around the seal's body[2]. Examination of pups restrained in the sea showed that no film of air was trapped around the body, nor was one seen when the hind-flippers of pups, anæsthetized with chloral hydrate, were immersed in sea-water. Numerous small bubbles were held at the base of the hairs, in the orifice of the follicle, but were easily removed by gently running the fingers over the body. However, air bubbles which were sometimes retained in the burrows were not so easily removed.

Another suggestion has been that oxygen is obtained from air bubbles or from a film of air trapped between the characteristic setæ and scales found on this type of louse[3]. When lice were immersed in sea-water, a small bubble of air was occasionally attached to a seta but not necessarily to one of those surrounding the spiracles. More frequently, no bubbles were present and, as the cuticle of the louse was easily wetted, a film of air was not held around the insect. When completely wetted and immersed in fresh sea-water at about 10° C. the lice remained alive for more than two weeks.

As the cuticle is thin and transparent a microscopical examination of living lice in sea-water was made with transmitted light. Only abdominal spiracles were seen, with trachea leading from the anterior of the abdominal tracheal trunks to each of the limbs and the head. It was found that when a spiracular opening was surrounded by an air bubble regular contractions of the atrium commenced. When the bubble was removed these contractions ceased within a few hours. During this period no water was seen to enter the atrium, which was filled with a bubble of gas, some of which was occasionally expelled. As no other structure was seen which could have a respiratory function, it would appear that oxygen is obtained from sea-water by diffusion through the cuticle.

There appears to be no reason to doubt that sufficient oxygen can be absorbed through the cuticle. At the greatly reduced metabolic rate associated with the lowered temperature in sea-water, little oxygen would be required and the surface waters in the sub-Antarctic are usually more than 80 per cent saturated with it[4]. Moreover, the surface area of the cuticle of these lice is greatly increased by deep clefts in the intersegmental regions of the thorax and abdomen.

One function of the setæ, which in the living insect stand erect from the cuticle, is probably to maintain a space between the cuticle of the louse and the walls of the burrow in the seal's skin. This would enable a film of water to be maintained around the insect through which gaseous diffusion can take place. Also, any air bubble trapped in the burrow around the louse would be maintained and act as a gill.

It is hoped to continue these investigations and the co-operation of any biologist who intends to visit the sub-Antarctic would be most welcome.

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Natural Relationships of the Nitrogen-fixing Bacteria

In a recent publication, Hino and Wilson[1] describe the fixation of nitrogen by a bacterium strongly resembling *Bacillus polymyxa*. The significance of this finding should not escape notice, as it has an important bearing upon a long-standing controversy.

The existence of a Gram-positive, sporogenous form of *Azotobacter* was demonstrated by Löhnis and Smith[2] but their claims were disregarded. Much later, I showed[3] that many strains of *Rhizobium* pass through a Gram-positive, sporogenous phase, and expressed the opinion that this genus is related to *Bacillus polymyxa*. Afterwards, the work of Löhnis was confirmed and extended[4], and it was concluded that *Azotobacter* and *Rhizobium* are both specialized members of the Bacillaceae; with the important corollary that they were thus shown to be closely related to *Clostridium*, many species of which are capable of fixing nitrogen[5].

The members of the *Bacillus polymyxa* group differ from other aerobic sporing bacilli in possessing a clostridial spore and in producing gas from carbohydrates, but they share these characters with *Clostridium* and with the sporogenous strains of *Rhizobium* and *Azotobacter*. It now appears that they also share the ability to fix nitrogen.

Since it is very often stated that morphology is of limited value in the classification of bacteria, it is worth placing on record that the evidence which led me to the conclusion that *Bacillus polymyxa* is closely related to the nitrogen-fixing bacteria was almost entirely morphological.

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Growth-promoting Activity of Potato Tuber Extracts in the Coleoptile Straight-Growth Test : Quantitative Aspects of Indoleacetic Acid Detection

The development of relatively simple techniques for the chromatographic separation of growth-active fractions from plant extracts, and their detection by chromogenic reagents, has led to the conclusion that indoleacetic acid and other indole compounds are the principal naturally occurring growth substances, as detectable in the coleoptile straight-growth test. In many instances, however, the characterization of growth-active fractions as indole or non-indole compounds has been based on insufficient evidence, or lack of awareness as to the sensitivity or specificity of the techniques used. For example, the growth activity in extracts of potato tubers has been ascribed to the presence of several indole compounds[1-3], yet no single investigator has demonstrated a correlation between colour reaction and biological activity for chromatograms developed in a number of solvent systems.

During the course of an investigation into the growth-substances present in developing and stored potato tubers, it was found that in the ether fractions from approximately fifty separate ethanol extracts there was present only one promoter of coleoptile growth. This ran at the position of indoleacetic acid in *iso*propanol : ammonia : water, butanol : ammonia: water, butanol : acetic acid : water, and ethanol : formic acid : chloroform : water solvents. Nevertheless, even when a 500 gm. fresh weight equivalent was chromatographed on a 10 cm. wide paper and strips from this sprayed with Ehrlich's reagent a colour reaction was not given. The failure of the growth-substance to give an indoleacetic acid colour reaction with chemical reagents, even though it appeared to be identical with the indoleacetic acid from chromatographic evidence, was investigated further as it seemed possible that the amount present might be below the minimum quantity detectable with such reagents. Known quantities of indoleacetic acid were distributed over 3 cm.^{2} areas of filter paper and sprayed with reagent ; from 0·2 to 0·5 μgm. indoleacetic acid gave a faint, transient colour with Ehrlich's reagent and 5 μgm. was required to give a strong, more permanent colour. Salkowski's reagent was slightly less sensitive. From the results of bio-assay and assuming that the promoter was indoleacetic acid, it was determined that a little less than 1 μgm. would be present in the 500 gm. equivalent tuber fraction and, as 10 cm. wide paper was used, this was distributed over an area of 30 cm.^{2}. This concentration, although giving considerable growth stimulation on bio-assay, would therefore be well below the limit of detection with chemical reagents. In order to be certain of getting a colour reaction, if the promoter was indoleacetic acid, it was calculated that the extract from 3 kgm. of tubers would have to be localized in an area of 3 cm.^{2} of paper. This was achieved by repeated chromatography and elution, and with Ehrlich's reagent a colour reaction typical of indoleacetic acid was given. Recently it has been shown that some sugars[4] and other compounds[5], probably leucoanthocyanidins, give colour reactions which may be confused with those given by indoleacetic acid. These substances were not responsible for the colour reaction of the potato extracts.

It is clear from the results relating to the sensitivity of the chemical reagents used for the detection of indole compounds that care must be taken to use a sufficient quantity of material in order to detect a chromogenic reaction. The failure of certain other workers to obtain colour reactions at growth-promoting zones running at the same position as indoleacetic acid on chromatograms might well be due to lack of material.

In the present investigation it appeared that the only ether-soluble growth promoter of potato tubers was indoleacetic acid. The discrepancies between the present results and those of earlier workers, who reported two or three further indole compounds, may be a consequence of differences in extraction technique. In this work material was frozen solid, powdered and allowed to thaw in ethanol. Under these conditions the tissue remained perfectly white throughout extraction. *p*H adjustment was not made during extraction or in the separation of an initial ether fraction ; but a further ether extract, made at *p*H 3, yielded no other promoters.

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δ-Acetylornithine : a Constituent of some Common Grasses

Two acetylornithines have been identified as natural products. α-Acetylornithine is accepted as an intermediate in the major pathway in the biosynthesis of ornithine from glutamic acid in *Escherichia coli* and has been isolated from culture filtrates of a mutant strain of this organism requiring ornithine[1]. δ-Acetylornithine was isolated somewhat earlier from the roots of *Corydalis ochotensis* by Manske[2]. It is also present in *Corydalis bulbosa*, and has been isolated as its dihydrochloride from the fern, *Asplenium nidus*[3]. In a private communication, Prof. K. Mothes tells me that he and Dr. G. Reuter have extended Manske's findings and have shown that δ-acetylornithine is present in large amounts in nearly all the members of the Fumariaceae (of which *Corydalis* is a member) that they have examined.

No information is as yet available to indicate the way in which δ-acetylornithine is implicated in intermediary plant metabolism. This may be due largely to the unsuitable nature for metabolic experiments of the plants from which it has been isolated. Therefore it seems appropriate to report that the amino-acid has now been identified as a constituent of a number of common grasses of the tribe Festuceae. In order to confirm its chemical character it was isolated from a representative member of these species, *Brachypodium sylvaticum*.

By means of cation-exchange resin ('ZeoKarb' 215) and paper partition chromatography, approximately 50 mgm. of δ-acetylornithine were isolated from an aqueous ethanolic extract of 500 gm. of macerated leaves of *Brachypodium*. The identity of the substance was confirmed by elementary analysis (found : C, 48·0 ; H, 8·2 ; N, 15·8 ; calculated for δ-acetylornithine, $C_7H_{14}O_3N_2$: C, 48·3 ; H, 8·0 ;

N, 16·1 per cent), and by comparison with authentic samples of δ-acetylornithine obtained from Profs. K. Mothes and A. I. Virtanen. The substance from *Brachypodium* was inseparable from δ-acetylornithine when run on paper chromatograms developed in four different solvent systems. In contrast, it could be separated from α-acetylornithine (kindly supplied by Dr. H. J. Vogel) on chromatograms developed in *n*-butanol/acetic acid mixture and in 70 per cent (v/v) *n*-propanol. The isolate had a melting point of 265° C.; no depression of the melting point resulted when the isolate was admixed with δ-acetylornithine (melting point, 265–266° C.). When hydrolysed with *N* hydrochloric acid at 100° C. for 24 hr., the isolate gave rise to ornithine which was identified chromatographically.

Although δ-acetylornithine is normally a major component of the free amino-acid pool of the members of the Fumariaceae, it was a relatively minor component of *Brachypodium* and, in the grasses examined, it never accumulated in concentrations comparable with those of certain of the common protein amino-acids. δ-Acetylornithine was not present in the leaves of two common cereals examined. Small amounts of another amino-acid, provisionally identified as α-aminoadipic acid, were found in the extracts of most of the grasses. The relative amounts of δ-acetylornithine and α-aminoadipic acid present in each species are listed in Table 1. Occasionally β-alanine or pipecolic acid also was found in an extract together with many of the normal protein amino-acids.

Table 1. Relative Amounts of δ-Acetylornithine and α-Aminoadipic Acid in Extracts prepared from Leaves of Various Grasses

Species	δ-Acetyl-ornithine	α-Amino-adipic acid	Other acids
Agropyron repens	*	*	β-Al: *W*
Brachypodium sylvaticum	*M*	*W*	*
Bromus carinatus	*	*W*	*
Dactylis glomerata	*	*W*	PA: *M*
Festuca heterophylla	*W*	*W*	*
Lolium perenne	*T*	*W*	β-Al: *W* PA: *M*
Poa glauca	*S*	*W*	*
P. nemoralis	*M*	*W*	*
P. alpina	*W*	*W*	*
P. pratensis	*M*	*W*	*
Puccinellia maritima	*M*	*	*
Barley (*Hordeum vulgare*)	*	*W*	*
Oats (*Avena sativa*)	*	*T*	*

Key: *S*, relatively large amount; *M*, moderate amount; *W*, small amount; *T*, trace amount; * not detected; β-Al, β-alanine; PA, pipecolic acid.

The ready availability of seeds of a number of the grasses investigated and the vigour with which they grow should make these species more suitable than the Fumariaceae for future study of the way in which δ-acetylornithine metabolism is related to the basic, well-established patterns of nitrogen metabolism in the higher plant.

My thanks are due to Miss J. Chessun for technical assistance.

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June 5.

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Photoperiodic Response of the House Sparrow, *Passer domesticus*

Forty-six male sparrows were divided into two groups and placed in light-tight cages 6 ft. × 6 ft. × 6 ft.

Group 1. Twenty-four birds were given a photoperiodic treatment of 7 hr. light and 17 hr. darkness per 24-hr. period. Light was from two 40-watt daylight fluorescent tubes which gave never less than 7 ft.-candles in any part of the cage. Group 2. Twenty-two birds were given a photoperiodic treatment of 1 hr. light and 23 hr. darkness per 24-hr. period. Light was from a single 15-watt incandescent bulb which gave 1 ft.-candle or less on perches and floor.

The experiments were started in February 1957 and two specimens were taken from each group every month. Testis volume was obtained from measurements of the axes of the organs immediately upon dissection and afterwards sections were cut at 5μ and stained to show the stages of spermatogenesis. In addition, as many wild controls as it was possible to obtain were collected in the immediate environment and were given the same histological treatment as experimentals.

The testis volume and stage of spermatogenesis of controls, group 1 and group 2 are shown in Figs. 1 and 2. It is concluded that:

(1) The minimal threshold-level in respect of photoperiod is down to at least 1 hr. in this species.

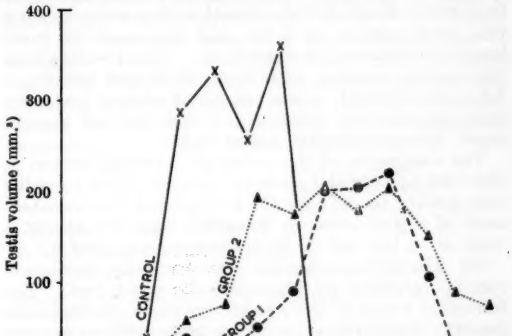

Fig. 1. Testis volume. Groups 1 and 2, average of two specimens each month. Control, average of all specimens each month

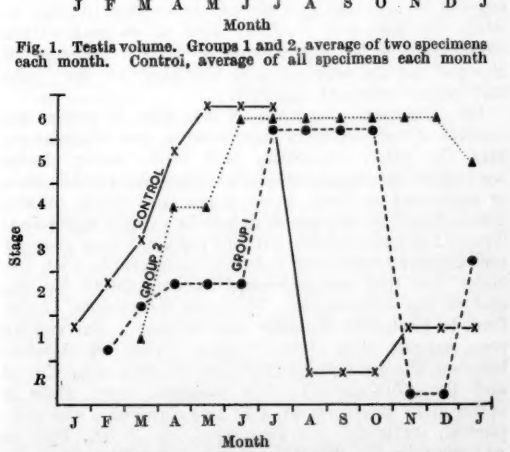

Fig. 2. Spermatogenesis. Groups 1 and 2, maximum stage of spermatogenesis of two specimens each month. Control, maximum of all specimens each month

This level is very much lower than has previously been recorded for any other bird. Bartholomew[1] considered 10 hr. to be close to the minimal level for the sparrow, but subjected birds to this photoperiod for only 46 days.

(2) The effectiveness of a photoperiod is dependent not only on its length but also on the duration of its application. In both group 1 and group 2 only slight testicular response was evident after 4 months and 3 months respectively. In estimating the minimal photoperiodic threshold for any bird, therefore, it appears necessary to conduct experiments for at least 6 months.

(3) The relationship between length of photoperiod and time of maximum testicular response, that is, production of spermatozoa, does not seem to be a straight-line correlation. Further research may show this relationship to be parabolic, with the minimal response centred at a 7- or 8-hr. photoperiod and the response increasing from this low in both directions.

(4) The duration of production of spermatozoa appears to bear a certain inverse relationship to the length of the photoperiod. On 1 hr., spermatozoa were produced for 214 days, with 7 hr. for 122 days and under natural conditions for 98 days. A relationship between photoperiod and duration of spermatogenesis has been noted by Burger[2] for the starling. In this bird the rate of testicular activation increased from 8·5 to 24 hr. but the duration of spermatogenesis was maximum at 12·5 hr. and decreased for both longer and shorter photoperiods. The results given here are in contrast with those of Burger because a 1-hr. photoperiod, when compared with a 7-hr., not only extended its duration but also induced a more rapid spermatogenetic activation.

The extension of the potential breeding season in this bird by artificial means is only the third recorded case known to me. Wolfson[3] reported the maintenance of active testes in Fringillid birds for almost a year on 12 hr. and on 20 hr. starting on April 6.

(5) The inherent tendency to testicular involution can be modified by photoperiodic treatment. The tendency seems to be 'put off' by short photoperiods (see 4). Furthermore, recovery from collapse is more rapid under a short photoperiod and this is shown in group 1, where only 1 month after complete regression, spermatogenesis had proceeded to stage 3, while the testes of controls were at stage 1. This conclusion is in agreement with the findings of Burger[2] for the starling and Wolfson[4] for the junco and white crowned sparrow.

(6) The testicular cycle of this bird is under the control of two separate mechanisms, one stimulatory and the other inhibitory but both under photic control. The separateness of these two mechanisms is indicated in that more rapid activation of the testes does not necessarily result in a rapid regression. Group 2 showed a more prompt response than group 1 and attained testicular volumes comparable with the latter but had not regressed as completely by the end of the experiment. It seems reasonable, therefore, to postulate separate mechanisms. The results here suggest that there is some direct relationship between the amount of inhibitory substance produced and the photoperiod; for example, very little is apparently produced by 1 hr., as regression was only partial, sufficient for regression by 7 hr., but as re-activation of the testis is rapid, its effect must be soon destroyed, and most under natural conditions when, after collapse in August, reactivation does not occur until November or December. There is, therefore, some suggestion that the effectiveness of the inhibitory substance is destroyed by long nights.

The results of these experiments are very similar to those I have already obtained in respect of the pigeon *Columba livia* (unpublished). Further experiments are, of course, necessary, and the following are at present in progress: 1 hr. light and 23 hr. darkness and 4 hr. light and 20 hr. darkness, both with an intensity of not less than 7 ft.-candles; 4 hr. light and 20 hr. darkness with an intensity of 1 ft.-candle or less on perches and floor. It is hoped to publish a full report of these results together with those of the new experiments when the latter are completed.

This work was carried out while I was the holder of a National Research Council of Canada Post-Doctorate Fellowship. I wish to express my appreciation to Dr. H. I. Battle, for providing laboratory and other research facilities in the Department of Zoology, University of Western Ontario.

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March 19.

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The Hood of the Hooded Seal, *Cystophora cristata* Erxl.

It is well known that the male of the hooded seal, *Cystophora cristata*, can inflate its hood, which is the greatly enlarged skin of the snout. It is also known that the male hooded seal can extrude an assumed pair of fiery red bladders or balloons through his nose. The presence in the nose of two evertible cœca, which would apparently be turned inside out in much the same way as glove-fingers, was claimed by Mohr[1] from the study of a museum specimen.

Having spent a few seasons on Norwegian commercial sealers in East Greenland waters I am able to throw additional light on this particular feature. Although I looked particularly for the evertible cœca, no such structures could be found on freshly killed animals. On several occasions I had the opportunity to examine males which were known with certainty to have extruded a fiery red bladder just prior to capture.

Having questioned several skippers and gunners, and having at last seen the phenomenon myself, I am now certain that one bladder only is extruded. Some of the skippers, who have excellent opportunities to observe the animals from the mast-head, state that when the bladder is beginning to be extruded it looks as if two are present, but, when fully inflated, one only is seen. It appears that the bladder is divided distally into two lobes, the whole structure in the inflated state being heart-shaped when viewed from above.

In males having a well-developed hood, the mucous nasal septum which divides the nasal cavity into two equal halves is also very well developed and is rather thick and elastic, the cartilaginous nasal septum remaining short. The extrusion of the bladder may be explained as follows: by closing one nostril, and by blowing out air through the nose, the mucous nasal septum is made to bulge into the opposite half

of the nasal cavity and is extruded through the opposite nostril as a red bladder. The extrusion of this bladder appears to be confined to the breeding and mating season in the spring.

Nothing in the work of Brönsted[2] is thought to be contrary to the view expressed here.

It would be of interest to know if the male elephant seal, *Mirounga leonina*, the proboscis of which is similar to that of the hooded seal, can extrude a bladder through the nose in the same way.

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Institute of Marine Research,
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Genetic Hazard of Ionizing Radiations

IN current estimates of the genetic hazard of ionizing radiations to man[1,2] four important assumptions are made: (1) that the mutagenic effect of a given radiation dose to the gonads is independent of dose-rate; (2) that the relationship of mutation-rate to accumulated dose is linear; (3) that the spectrum of radiation-induced mutation is similar to the spectrum of spontaneous mutation, and (4) that a dose of about 30–80 rads induces as much mutation as occurs spontaneously per generation ('doubling dose'). Assumptions (1), (2) and (3) derive largely from experiments with *Drosophila*; assumption (4) derives in part from the fact that a spermatogonial doubling dose of this order was estimated for seven specific genes in the mouse from observations of the spontaneous mutation-rate[3,4] and from experiments[4] in which adult males were given a high X-ray dose at a high dose-rate (600 rads, 90 rads/min.), the validity of assumptions (1), (2) and (3) being presupposed.

However, Russell and Kelly[5] have recently stated that they have found a much lower induced spermatogonial mutation-rate at these loci when the dose of 600 rads was given as cæsium-137 γ-rays at a low dose-rate than when it was given as 250 kV. X-rays at a high dose-rate. This means that for mouse spermatogonia one can no longer make assumption (1) and that estimates of the doubling dose will vary with the conditions of irradiation. Since man is likely to resemble the mouse more than *Drosophila* in this respect one can no longer make assumption (1) for man. Most genetically effective radiation exposure of man is due to low doses accumulated over an appreciable fraction of the life-span; it therefore becomes important to have some estimate, however rough, of the mutagenic effect of radiation delivered to the mouse under conditions more nearly comparable with those of most human exposure.

During the past ten years we have been carrying out two such experiments. In the present experiment young adult male mice accumulate 37·5 rads as cobalt-60 γ-radiation over 35 16-hr. nights. They are placed with females immediately after exposure and are bred for up to two years, so the great majority of gametes tested were spermatogonia at the time of exposure. Progeny of exposed and control males are scanned for recessive mutation at the *a*, *b*, *c*, *d*, *se*, *p* and *s* loci and for dominant visible mutation at any locus. The stocks and techniques used have been described elsewhere[6]. The results are summarized in Table 1, together with those from our earlier experiment[6] in which radium γ-rays were used. They yield an estimate of 95 rads for the doubling dose for the seven specific loci, which is higher than previous estimates[1,3] by a factor of 2 or 3. However, the lower 95 per cent confidence limit[7] is only 10 rads and therefore the data do not warrant any change in assumption (4). More than anything else they show the enormous numbers of animals that must be raised in low-dose mutagenesis studies: clearly at least a million more mice must be scanned before we shall have an estimate of the spermatogonial doubling dose that approaches precision.

Table 1

Dose (rads)	Progeny scanned	Specific locus mutations *a*	*b*	*c*	*d*	*se*	*p*	*s*	Total	Dominant visibles
0	18,355*	0	0	0	1	0	0	1	2	0
0	99,372†	0	1	0	3	‡	1	1	6	2
37·5	10,024*	0	0	0	0	0	0	1	1	0
37·5	53,298†	0	2	0	3	0	0	0	5	1

* Data from ref. 6; radium γ-rays used.
† Includes data from ref. 3: cobalt-60 γ-rays used.
‡ Two of the *d*-mutants were also mutant at the closely linked locus *se*. These have been counted as single mutational events in the analysis.

These results have a bearing also on assumption (3). In our experiments *d* has been the most mutable locus, there having been as many mutations at this locus alone as at the other six loci together; but in his high-dose, high-dose-rate experiments Russell[4] found only six *d*-locus mutations among a total of 54, the most mutable locus being *s*, with 25 mutations. Thus in this small sample of loci the spectrum of mutation induced by a high acute dose, on one hand, differed from that of spontaneous mutation and mutation induced by a low chronic dose, on the other. Clearly the validity of assumption (3), as applied to larger samples of loci, requires further test.

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RITA J. S. PHILLIPS

Medical Research Council
Radiobiological Research Unit,
Harwell. June 4.

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Possible Autosomal Linkage in Man

FAMILIAL intestinal polyposis is known to be an inherited dominant disease[1]. Most families die out after a few generations as the condition frequently causes death before reproduction has occurred, and affected individuals often refrain from marriage because of the danger of passing the condition on to their offspring.

In New Zealand a pedigree is being studied which consists of nearly two hundred individuals covering six generations. This pedigree contains eight families segregating for polyposis. A preliminary investigation, designed to test for possible linkage relations, has suggested that the polyposis gene may be closely linked to the *MN* locus. The method used is that described by

Finney[3]. Of the eight families, one must be rejected as the parent with polyposis is group *M*, and in three families the parent affected with polyposis died before the investigation was begun and examination of the offspring is not sufficient to be able to determine the mating type with certainty. One further family of Finney's mating type 4 has only two offspring, one of which is group *MN* and so cannot contribute to the linkage test. The remaining three families appear in the analysis of Table 1, which follows Finney's scheme.

Table 1

Family	Mating type	a	b	c	d	$\lambda = \frac{1}{4}u_{11}$	$K_c = \omega_1$
III (1)	4	2	0	0	0	1·00	1·00
III (5)	4	0	1	3	0	6·00	6·00
III (8)	3	1	0	0	1	1·00	1·00
						$S(\lambda) = 8·00$	$8·00 = S(K_c)$

$$\frac{S(\lambda)}{\sqrt{S(K_c)}} = \frac{8}{\sqrt{8}} = 2·828; \quad P < 0·01 \quad (1 \text{ per cent point} = 2·33)$$

An attempt has been made to include three 'uncertain' families using Finney's technique for test factors showing dominance, but as some of these families are now part-Maori in origin and the gene frequencies for *M* and *N* are not known for Maoris, the results can be only tentative. However, the significance of the results does not seem to be affected by the inclusion of these families using estimated gene frequencies, and an estimate of the recombination fraction shows that the linkage is close (probably less than 5 per cent).

This pedigree will yield further information during the next ten to twenty years as a number of families too young for any member to have developed polyposis have already been extensively examined for blood group and from time to time they will be examined for polyposis.

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Migration of Spleen Cells from Subcutaneous Implantation Sites

Particulate matter and cells injected subcutaneously are normally localized at the site of injection, while the suspending medium diffuses outwards[1]. Exceptional behaviour might be expected of cells from the bone marrow and spleen, however, for these cells can become established in homologous tissues after intravenous injection into irradiated hosts[2]. On the other hand, the intravenous route of injection is more effective than the subcutaneous in procuring the functional survival of these cells, as judged by protection against lethal irradiation[3], and the adoptive transfer of immunity[4]. The continued production of a specific antibody by spleen cells was used in the present experiments, to determine their localization after subcutaneous implantation.

Spleen cells were transferred from immunized mice of the *CBA* strain into adult non-immunized hosts of the same strain. Immunization was carried out by intravenous injection of *Salmonella typhi* (H), according to Mitchison's procedure[5]. The spleen cells were suspended in saline and injected subcutaneously into the flank, at a dose equivalent to one whole spleen into each host. At intervals after transfer, the *H*-agglutinins in the serum of the hosts were titrated (Fig. 1). One group of hosts received frozen and thawed cells. In the other hosts the cells remaining at the subcutaneous injection site were either removed surgically after an interval, or were left undisturbed.

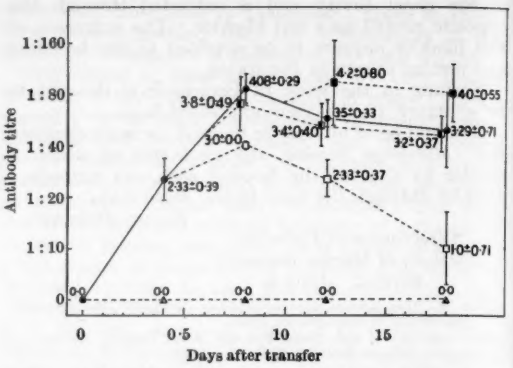

Fig. 1. Antibody titres of sera from host mice after transfer of spleen cells (means with standard deviations from 3–7 mice). Untreated cells, ●——●; subcutaneous site removed on fourth day, □- - -□; subcutaneous site removed on sixth day, ◧- - -◧; subcutaneous site removed on tenth day, ■- - -■; frozen-thawed cells, △- - - △

No antibodies were detected in the hosts after injection of cells that had been frozen and thawed, indicating that no significant quantities of antigen or pre-formed antibody had been transferred with the cells. The appearance of antibodies in the other hosts can therefore be attributed to synthesis by the transferred cells; antibody synthesis occurred, although at a lower level than after transfer of comparable cells by the intraperitoneal route[6]. Removal of the cells at the injection site on the fourth day after transfer was followed by a drop in antibody titre, whereas removal on the sixth or tenth day was without significant effect. It appears, therefore, that functionally active cells were still present at the subcutaneous site up to the fourth day, but that the active cells later migrated elsewhere—presumably into the regional lymph nodes.

Histological examination confirmed the absence of active cells from the subcutaneous site after the fifth day. The remaining lymphoid cells were gradually degenerating and dying, within a well-defined, generally encapsulated nodule. Holub has described similar nodules in the omentum of young rabbits after intraperitoneal injection of lymphoid cells[6].

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APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

ASSISTANT LECTURER (with a degree in physiology or veterinary surgeon) IN THE DEPARTMENT OF PHYSIOLOGY—The Secretary, Royal Veterinary College, Royal College Street, London, N.W.1 (August 15).

LECTURER IN INDUSTRIAL ADMINISTRATION—The Registrar, Manchester College of Science and Technology, Manchester 1 (August 16).

ASSISTANT PHYSICIST (Basic or Senior grade), for duties concerned with routine radiotherapy physics and the clinical use of radioactive isotopes, with opportunities for research in the clinical application of radioisotopes—The House Governor, Charing Cross Hospital, London, W.C.2 (August 18).

SENIOR LECTURER (with a university degree, teaching and/or research experience together with a knowledge of tropical soils) IN SOIL SCIENCE in the Department of Agriculture, Kumasi College of Technology—The Council for Overseas Colleges, 12 Lincoln's Inn Fields, London, W.C.2 (August 22).

LECTURER (Grade I or II) IN PLANT PATHOLOGY in the Department of Agriculture, University College, Ibadan, Nigeria—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (August 25).

LECTURER IN CHEMISTRY; and a SENIOR LECTURER IN EDUCATION at Fourah Bay College (University of Durham), Sierra Leone—The Council for Overseas Colleges, 12 Lincoln's Inn Fields, London, W.C.2 (August 29).

LECTURER IN MATHEMATICS (PURE MATHEMATICS) at the University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, August 29).

ASSISTANT LECTURER (preferably with an interest in research in the general field of ionized gases) IN PHYSICS—The Registrar, University College of Swansea, Singleton Park, Swansea (August 30).

JUNIOR LECTURER IN MATHEMATICS—Professor E. C. Titchmarsh, Mathematical Institute, The University, Oxford (August 31).

PHYSICIST, Senior Scientific Officer grade (with a good honours degree in physics, general physical experience, and a knowledge of radiochemical equipment), in the Scientific Branch at County Hall, for research work on properties of materials and in the field of health physics—Medical Officer of Health (PH/D.1/A), County Hall, London, S.E.1 (September 1).

PHYSICIST (with a university degree in science, applied science or engineering, or a technical college diploma or equivalent qualifications and preferably some practical experience in instrumentation, electronics or vacuum techniques) IN THE DIVISION OF FOOD PRESERVATION AND TRANSPORT, C.S.I.R.O., Homebush, New South Wales, Australia, to participate in investigations of the relation between the vapour pressure and the water content of biological materials, and in the development and assessment of objective methods for measuring differences in colour between samples of particular foodstuffs—Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2, quoting Appointment No. 300/207 (September 1).

SENIOR RESEARCH ASSISTANT (Ph.D. standard and preferably some experience of electronics and/or low temperature work) IN PHYSICS, for a programme of work on the magnetic properties of thin films—The Principal, Royal Holloway College (University of London), Englefield Green, Surrey (September 1).

RESEARCH ASSISTANT or JUNIOR FELLOW IN AERONAUTICAL ENGINEERING—The Registrar and Secretary, The University, Bristol (September 8).

LECTURER IN PHILOSOPHY at the University of Auckland, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand, September 15).

STUDENTS AND FELLOWS, for research in various topics in physical metallurgy, mainly related to nuclear energy, and including irradiation damage, brittle fracture, corrosion of uranium, transformations in uranium alloys, ageing in aluminium alloys, and deformation of semiconductors—Prof. J. G. Ball, Metallurgy Department, Imperial College of Science and Technology, London, S.W.7 (September 19).

SENIOR LECTURERS (2) AND A LECTURER IN THE DEPARTMENT OF BIOCHEMISTRY, University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, September 30).

SENIOR RESEARCH OFFICER (graduate, with research experience in amino-acid and protein chemistry) IN BIOCHEMISTRY, to undertake research on the proteins of the wheat grain—The Registrar, University of Melbourne, Carlton N.3, Victoria, Australia (September 30).

LECTURER IN AGRICULTURAL CHEMISTRY at the University of Melbourne, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, October 10).

RESEARCH STUDENTS AND FELLOWS IN PHYSICS at the University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, November 15).

ASSISTANT PROFESSOR or ASSOCIATE PROFESSOR (with a Ph.D. degree in organic chemistry, and preferably research interests in the chemistry of natural products) IN THE DEPARTMENT OF CHEMISTRY—Prof. C. A. McDowell, Department of Chemistry, University of British Columbia, Vancouver 8, B.C., Canada.

BIOCHEMIST, for research on problems connected with the composition, enzyme activity and metabolism of healthy and infected leaves at different stages of growth—The Secretary, Rothamsted Experimental Station, Harpenden, Herts.

BIOCHEMIST (preferably with postgraduate experience), for research into lipoprotein metabolism in childhood diabetes—H. B. Salt, Department of Biochemistry, Children's Hospital, Birmingham 16.

CHEMICAL ENGINEERS (with an honours degree or equivalent and significant experience in chemical engineering research), to develop processes and pilot plants in connexion with radioactive substances—Group Recruitment Officer (1179/2), Atomic Energy Research Establishment, Harwell, Didcot, Berks.

EXPERIMENTAL OFFICER (with a good knowledge of general laboratory technique and experience in the research field) AT THE MILK MARKETING BOARD'S DEEP FREEZE UNIT at Northampton, to be responsible for the handling and freezing of bull semen—The Personnel Officer, Milk Marketing Board, Thames Ditton, Surrey.

GRADUATE ORGANIC CHEMISTS (2) to join a team investigating a problem in the field of wood chemistry—The Director, Arthur D. Little Research Institute, Inveresk Gate, Musselburgh, Midlothian, Scotland.

LECTURER, Grade B (graduate of a British university), IN MATHEMATICS—The Clerk to the Governing Body, Battersea College of Technology, London, S.W.11.

LIBRARIAN (under 55, with an honours degree in science and preferably some training in geology) IN THE GEOLOGICAL SURVEY DEPARTMENT, Federation of Nigeria, for duties which include organizing, indexing and maintaining the Department's library, map collection and technical records; assisting in the collection and abstracting of information on geological research and in the preparation of Geological Survey publications—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.105/14/010/T.

MECHANICAL ENGINEER (professionally qualified and with sound experience in the maintenance and operation of engineering plant and equipment), initially to inspect, accept and commission mechanical plant for the 7 GeV. Proton Synchrotron and, later, to organize and control operation, maintenance and modification of that plant—Group Recruitment Officer (1168/2), Atomic Energy Research Establishment, Harwell, Didcot, Berks.

RESEARCH ASSISTANT (physicist, preferably with research experience and a knowledge of electronics), for work on development of methods of temperature measurements in shock tubes—Dr. A. G. Gaydon, Chemical Engineering Department, Imperial College of Science and Technology, South Kensington, London, S.W.7.

RESEARCH ASSISTANTS IN THE DEPARTMENT OF CHEMISTRY, for experimental work on the thermodynamic properties of mixtures—The Registrar, The University, Reading.

SENIOR LECTURER (well qualified in physics and prepared to teach to the level of the Diploma in Technology in Applied Physics) IN PHYSICS—The Principal, Brunel College of Technology, Woodlands Avenue, London, W.3.

WILLIAM DICK CHAIR OF VETERINARY SURGERY—The Secretary, The University, Old College, South Bridge, Edinburgh 8.

ZOOLOGIST or PHYSIOLOGIST (graduate), to assist in the British Empire Cancer Campaign research on the biology of cancer, including tissue culture—The Administrative Officer, Mount Vernon Hospital, Northwood, Middlesex.

REPORTS and other PUBLICATIONS

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